ANTIQUITY OF GOLD MINING IN KARNATAKA

A GEOARCHAEOLOGICAL EVALUATION

THESIS SUBMITTED BY

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Declaration

I do hereby declare that the thesis entitled "Antiquity of Gold Mining in Karnataka: A Geoarchaeological Evaluation", which I am submitting to the University of Mysore, Mysore, for the award of degree of Doctor of Science, is the original work carried out by me in Geological Survey of India. I hereby declare that this work has not been submitted earlier in this or in any other University or Institute and does not form the basis for the award of any other degree.

T.R. Anantharamu 20/1/96

(T.R. Anantharamu)

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Contents

CHAPTER 1. INTRODUCTION

1.1	THE IMPORTANCE OF GOLD	1
1.1.1	Gold and gold alloys	1
1.1.2	Abundance of gold	2
1.1.3	The lure of gold	2
1.1.4	Historical background	3
1.1.5	Aim and scope of the present work	4

CHAPTER 2. GEOLOGICAL SETUP AND GOLD MINERALISATION IN KARNATAKA

2.1	PRIMARY GOLD	7
2.1.1	Greenstone belts and gold mineralisation	9
2.1.2	Genetic classification of gold deposits of Karnataka	11

CHAPETER 3. ANCIENT GOLD WORKINGS

3.1.	THE EARLY SURVEYS	13
3.1.1.	The importance of ancient gold workings	14
3.1.2.	Definition of 'old ' and 'ancient' workings	17
3.2.	DISTRIBUTION AND STATUS OF ANCIENT WORKINGS FOR GOLD IN KARNATAKA	1
3.2.1	Kolar gold field	32
	Geological set up :	33
3.2.1.1.	Ore genesis	33
3.2.2	Gold mining activity in Kolar Gold Field	34
3.2.3	Hutti gold field	37
3.2.4	Magnitude of ancient workings in Hutti gold field	38

CHAPTER 4. PLACER GOLD

4.1	PLACER GOLD OCCURRENCES IN KARNATAKA	44
4.1.1	Gold panning in Gadag area	44
4.1.2	Gold Panning in Shimoga area	47
4.1.3	Gold panning in Bellary area	48
4.2	INSCRIPTION AND LITERARY REFERENCES FOR GOLD PANNING IN KARNATAKA	48
4.2.1	Place names connected with gold occurrences in Karnataka	51
4.2.2	Some place names and gold occurrences outside Karnataka	52

CHAPTER 5. ANCIENT MINING TECHNIQUES AND METALLURGY OF GOLD

5.1	FIRE SETTING : THE OLD PRACTICE	55
5.2	METHOD OF WINNING PRIMARY GOLD	57
5.3	A BRIEF REVIEW OF METHOD OF MINING	58

CHAPTER 6. ASH MOUNDS AROUND GOLD FIELDS AND THEIR RELEVANCE TO PREHISTORIC SETTLEMENTS

6.1.	ORIGIN OF ASH MOUNDS	60
6.1.1	Wandalli ash mound	61
6.1.2	Use of mercury for amalgamation	64
6.1.3	Gaudur ash mound	66

CHAPTER 7. NEOLITHIC SETTLEMENTS IN RAICHUR DISTRICT AND GOLD MINING ACTIVITY

7.1. The importance of neolithic settlements 69
7.1.1 Prehistoric sites of Raichur area 70
7.1.2 Earliest gold objects from the Deccan 71

CHAPTER 8. MEGALITHIC CULTURE AND ITS IMPORTANCE IN MINING

8.1 MEGALITHS FROM KOLAR AND HUTTI GOLD FIELDS 74
8.2 OVERSEAS TRADE AND GOLD SOURCE FROM KARNATAKA - A REAPPRAISAL 76
8.2.1 Rock edicts of Asoka and Gold mines 83
8.2.2 Influence of Ancient gold mining of Karnataka on the South African mining 87
8.3 A CRITICAL EVALUATION OF DIMALDINNE ASH MOUND OF KOLAR DISTRICT 88
8.3.1 Investigation around Patna 89
8.3.2 Investigation around Hunkund 90
8.3.3 Geological evidences 92
8.4 STUDY OF SLAG MATERIAL FROM DIFFERENT PARTS OF GOLD MINING AREAS IN KARNATAKA 94
8.4.1 Cheeranahalli slag samples 95
8.4.2 Ettinahatti slag samples 97
8.4.3 Chinmalgund slag samples: 99
8.4.4 The importance of iron smelting 100
8.5 BELLIBETTA : AN IRON AGE GOLD WORKING IN K.R.PET TALUK, MANDYA DISTRICT 102
8.5.1 Geographical location and brief geology 102
8.5.2 The early prospecting 103
8.5.3 Old workings as evidence for iron-age mining 103

CHAPTER 9. RADIOCARBON DATES OF GOLD MINES OF KARNATAKA

9.1 INTERPRETATION OF RESULTS 108
9.1.1 Gap in the record of gold mining activity 109
9.1.2 Gold mining in Tippu Sultan's regime 110
9.2 A COMPARATIVE STUDY OF MINING ARCHAEOLOGY OF METALLIFEROUS MINES OF INDIA 111
9.2.1. Radiocarbon dating for some basemetal mines of Aravali range 112
9.2.2 Radiocarbon dates for Copper mines of Singhbum, Bihar 114
9.2.3 Radiocarbon dates for copper mines of Karnataka 116

CHAPTER 10. SUMMARY AND CONCLUSION

10.1 SUMMARY 118
10.2 CONCLUSION 123

APPENDICES 129

REFERENCES 135

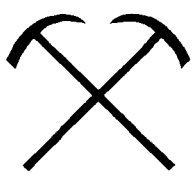
PLATES 150

Chapter 1

INTRODUCTION

Gold is where you find it

- Anonymous



1.1 THE IMPORTANCE OF GOLD

Gold is one of the first metals which attracted man in the early part of human history. one of the most sought after metals, gold has fascinated mankind throughout the ages. It is believed to have been used earlier than copper about 2000 years before Christian era. Its bright colour, ductility, malleability coupled with its resistance to tarnish are the qualities by which it has excelled other metals. By one gram of gold, a thin wire measuring 2.4 km. long can be drawn and one tonne of gold can be stretched from earth to the Moon and back. Gold is so malleable, that, from one centimetre thick gold sheet, 100,000 gold foils can be separated. The metal is so dense (Sp.gr.19.3) that whatever gold that has been mined from the earth for the past 6000 years (over 1,30,409 tonnes) can be accommodated in a cube measuring 20 m. on each side. One tonne of gold measures just 0.56 cu.m! Its high boiling point (2960°C.), conductivity and a very high reflectivity have commanded greater demand from the industrial sector. Gold continues to dominate in the present space age too, for, it has a variety of applications in the field of electronics.

1.1.1 Gold and gold alloys

In nature, gold occurs predominantly in the native state or as a major constituent of various alloys containing mainly silver, copper or platinum metals. Several gold and gold-silver tellurides are known of which the most common are sylvanite, calaverite, petzite, krennerite and nagyagite. The antimonide, aurostibite, $AuSb_2$, occurs in some auriferous deposits, and there is also an argentiferous gold selenide, fischesserite, Ag_3AuSe_2, an argentiferous gold sulphide. Uytenbogaardtite, Ag_3AuS_2, and a bismuthide, maldonite, Au_2Bi, which is fairly well differentiated. The principal ore minerals of gold are the native metal, aurostibite, and the various tellurides.

1.1.2 Abundance of gold

The abundance of gold in the upper lithosphere is about 0.005 ppm and the Au/Ag ratio is about 0.07. The average gold content of igneous type rocks in parts per million is ultramafic, 0.004; gabbro-basalt, 0.007; diorite andesite, 0.005; and granite-rhyolite, 0.003. The average gold content of sedimentary rocks in parts per million in sandstone and conglomerate, 0.03, normal shale, 0.004 and limestone 0.003. Certain graphite shales, sulphide schists, phosphorites and some types of sandstones and conglomerates may contain upto 2 ppm gold or more (Boyle 1987).

The average gold content of soils is 0.005 ppm, and the average for natural fresh waters is 0.00003. Sea and ocean water contains an average of 0.000012 ppm gold. Gold is a trace constituent of many plants and animals. Some plants are slightly enriched in gold, with 0.05 to 0.1 ppm gold in the ash.

1.1.3. The lure of gold

Boyle writes(1987 p.1) : Gold has been called the first folly of man, the whore of civilization, a barbarous relic, and a host of other fanciful, if at times, derogatory epithets. Nevertheless, man has retained a curious fascination for the metal for more than 5000 years, undoubtedly prompted by its great natural beauty and universal durability.

It was the lure of gold which turned men into explorers and again it was for gold, men have fought wars, resulting in blood sheds and suffered untold miseries to win the yellow metal.

Gold mining initiated techniques for mining of other metals. Greeks and Romans were the first to systematically explore this metal by underground mining. As far back as 6000 years, the Egyptians were mining primary gold in Nubia (Kavanaugh,1968).

The gold rush in the middle part of the 19th century, particularly in California, Ballart, Australia, Mexico and Russia added immense placer gold and changed the supply and demand pattern throughout the world.

The lure of gold is better expressed in statistics by Timoty Green (1968).

In the whole of the I century after Columbus discovered America the out put of gold totaled roughly 750 tons, in the last half of the 19th century, it was a mighty 10,000 tonnes.

1.1.4. Historical background

Today, India is not a major producer of gold compared to Market Economy Countries (M.E.C.). South Africa is producing gold to the tune of nearly 680 tons per annum and in India the present gold production has not crossed over two tonnes a year from both Hutti and Kolar gold mines.

In countries like U.S.A., Australia, the gold mining was started by placer mining and in India there was no gold rush in the middle part of the 19th century. This is because our ancestors had commendable knowledge about gold occurrence and majority of the gold mineralised zones were combed by them and today we largely see them as ancient workings spread over the entire auriferous tracts.

Karnataka is aptly described as 'The Land of gold' and is no exaggeration considering the fact that, it is the only state where, gold is actively mined from centuries, barring a limited production from Ramgiri mine of Andhra Pradesh. Besides, it also boasts as many as 57 locations with innumerable ancient workings where gold has been worked in different geological milieu by ancient people in the hoary past. All the gold occurrences in the state, like in other countries, are invariably dotted by ancient workings in the form of open pits, burrows, inclines, dumps, irregular

adits etc. which have served as guidelines for modern gold explorations- Kolar, Hutti and Gadag gold fields are no exception to this.

1.1.5 Aim and scope of the present work

Recorded systematic exploration for gold in the Indian sub-continent dates back to the end of nineteenth century, when Britishers ushered in this field in South India. The earlier mining history prior to this event is obscure in the mist of antiquity, we have only a few sketchy observations made by foreign travellers and historians prior to as well as in the post Christian era.

Precise understanding of ancient gold mining, fixing the chronology, is a field inviting scientific inquiry based on careful analysis of archaeological evidences vis-a-vis past human settlements in this part of the plateau.

In the present thesis, an attempt has been made to tie up geological, archaeological and epigraphical evidences, supplemented by literary references to decipher a meaningful mining history of yellow metal in Karnataka.

The work includes a systematic study and survey of ancient gold workings, specially, in Hutti, Kolar and K.R.Pet, schist belts, where there are numerous ancient workings.

The present thesis is developed on the following points

* Detailed study of Hutti-Maski schist belt, surveying most of the exposed old workings for gold, ash mounds and collection of archaeological evidences for mining.
* Systematic study of Dimaldinne ash mound in Kolar district where epigraphs have recorded possible gold smelting activity.
* Mapping of all the old workings for gold and delineating a cluster of old workings, deepening of old workings, panning of stream

sediments and detailed study of pounding marks in K.R.Pet schist belt, Mandya district.

* A systematic study of Gollarahalli old workings in the Nuggihalli schist belt and study of slag material from Chiranahalli in Hassan district, Ettinahatti in Bellary district and Chinmulagund in Dharwar district.

Field study of these aspects is augmented by systematic consultation of all the available data scattered in different publications and an attempt has been made to build up the sequence of gold mining in Karnataka. The methodology includes the following procedures.

a. Laboratory analysis of samples collected from ash mounds of Wandalli, Gaudur from Hutti belt, Dimaldinne from Kolar schist belt.

b. Systematic survey of technical reports available from different institutions, Departments which include :

i) Dept. of Mines and Geology - bulletins, memoirs and records.

ii) Geological Survey of India - research journals, memoirs, records and unpublished reports.

iii) Archaeological Survey of India - annual reports, records, epigraphs, inscriptions and ancient literature.

iv) Different literature both ancient and medieval comprising Kannada, Sanskrit and English works.

v) Annual issues of mining journals, London.

vi) Scientific papers dealing with ancient history and metallurgy available from the collections of Geological Survey of India at

Calcutta Headquarters including those published from Royal Asiatic society, Asiatic society of Bengal.

vii) Memoirs of Geological Society of India.

viii) Hyderabad Geological Survey - Annual reports and Journals (Nizam's period)

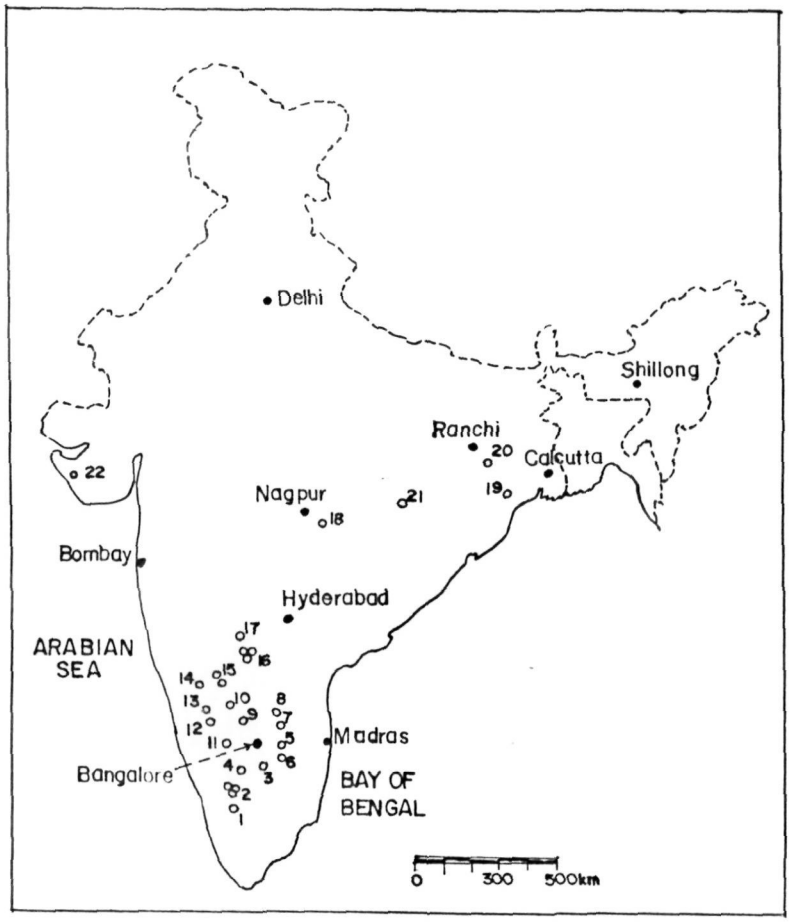
The data obtained is synthesised and properly arranged so as to reflect the history of evolution of gold mining in this part of the sub-continent.

Chapter 2

GEOLOGICAL SETUP AND GOLD MINERALISATION IN KARNATAKA

Gold has been called the first folly of man the whore of Civilization, a barbarous relic and a host of other fanciful, if at times derogatory epithets. Nevertheless man has retained curious fascination for the metal for more than 5,000 years undoubtedly promoted by its great natural beauty and universal durability

- Boyle, 1987



1. Attapadi
2. Wynad gold field
3. Kavudahalli-Porsedyke
4. Amble - Woolagiri
5. Kolar Gold Field
6. Mallappakonda-Chigargunta
7. Ramagiri Gold Field
8. Penkacharla
9. Bellara
10. Ajjanhalli-Javanagondanahalli
11. Kempinkote
12. Honnuhatti group
13. Kudrekonda-Palavanahalli
14. Chinmulgund-Haveri
15. Gadag Gold Field
16. Hutti Gold Field
17. Manglur Gold Field
18. Bhilwapur-Chandari
19. Telkoi-Banspal
20. Lava-Mayasara-Kuderkocha
21. Sonakhan
22. Alech Hills

PRIMARY GOLD DEPOSITS OF KARNATAKA AND OTHER PARTS OF INDIA

(Geological Society India 1991)

Fig 2 ·1

Karnataka craton is one of the oldest Precambrian terrains of the World, representing one of the earliest formed continental crust. It has preserved rocks ranging in age from 3.4 b.y. to 2.0 b.y. Based on stratigraphic and tectonic setting the Craton is classified into :

a. Ancient Supracrustals,

b. Auriferous schist belts of eastern Karnataka (Kolar type)

c. Younger schist belts of western Karnataka (Dharwar type)

The N-S trending closepet granite demarcates the boundary between the two blocks. The western block of the Craton, west of closepet granite represents gneissic rocks older than 3 b.y. and is surrounded by reactivated mobile belt made up of younger gneisses and granites ranging in age from 2600 m.y. - 2000 m.y. (Radhakrishna and Vaidyanadhan, 1994).

Gold occurs in a diverse geological set up in Karnataka. We have both primary and secondary deposits distributed in different geological milieu.

2.1. PRIMARY GOLD

The primary gold deposits of both vein and stratabound type are confined to : (Fig. 2.1)

1. The Dharwar greenstone belt of Archaean to early Proterozoic age (2100 m.y. - 3000 m.y.) comprising -
    a. Predominant volcanogenic eastern belt comparable to the Archaean greenstone belts of South Africa, Australia, Canada, Brazil representing rift phase - e.g. Kolar, Hutti-Maski, Mangalur schist belts.
    b. Sediment dominated western volcanic belt comparable to Archaean proterozoic basins and geosynclines of South Africa,

Australia and Canada representing platform phase. This includes Chitradurga, Shimoga, Bababudan and western ghat belts.

These two types are separated by a curvilinear closepet granite (Swami Nath *et al,* 1976).

2. The Granulite belt of Archaean age (2600 m.y. - 3200 m.y.) as represented by the granulite terrain on the southern end of the closepet granite, with rock formation consisting mainly of charnockite, diopside granulite - their retrograded equivalents, amphibolite, biotite hornblende gneiss, ferruginous quartzite, basic ultrabasic dyke, migmatites, syenites, where gold mineralisation is in fenites localised along N.N.E. - N.S. trending shears along which carbonatite-syenite activity has taken place.

3. Gold mineralisation associated with uranium in the quartz pebble conglomerate contribute more than 60% gold produced world over- e.g. Witwatersrand of South Africa, Blind river, Eliot lake of Canada, Tarkava conglomerate of Ghana, Jacobia conglomerate of Brazil where gold in the conglomerate is believed to be detrital. In Karnataka craton, quartz pebble conglomerate rests unconformably over the gneissic terrain containing enclaves of older auriferous schist. For example Bababudan conglomerate, Walkunje conglomerate and proterozoic basal conglomerate of Kaladgi.

4. In the ancient supracrustal (>3000 m.y.) occurring as narrow linear belts as rafts within the gneisses having high mafic and ultramafic components. They include the Sargur belt, Nuggihalli belt, Nagamangala and K.R.Pet belts.

2.1.1. Greenstone belts and gold mineralisation

In Karnataka, most of the productive gold mines are located in the greenstone belts of 2700 m.y. old.

Dharwar craton has 5,00,000 sq.km. area covered by greenstone belts, developed in southern part of the Craton.

The eastern greenstone belts comprising Kolar, Hutti-Maski, Mangalur, Hungund schist belts are characterised by volcanogenic rocks surrounded by tonalite, granodiorite, diorite, plutons with low pressure blanket metamorphism. The thick piles of meta volcanics are intercalated with subordinate sills of metaultramafites, minor acid volcanics euxenic carbonaceous schists, polymict conglomerate and banded iron formation.

Kolar shcist belt which has hosted the largest gold deposits in the country has two distinct type of lodes.

1. Lode gold-quartz-carbonate type ex. the Champion lode which is the richest gold bearing quartz lode so far encountered in India, localised along a shear zone traversing the mafic rocks of komatiite and tholeiite affinity. Lodes are mainly made up of quartz and calcite.

2. Stratiform sulphide type e.g. Oriental lode localised between volcanic flow and is formed of alternating bands of sulphide and amphibole quartzite with dominant pyrrhotite with subordinate arsenopyrite and minor pyrite and this carries less gold than the vein type.

In Hutti-Maski schist belt, ductile shears, filled with quartz-ankerite veins, traversing pillowed Fe enriched, low potash tholeiitic metabasalts have localised the gold mineralisation in association with pyrite, arsenopyrite and chalcopyrite. In addition, the contrasting contacts between

penecontemporaneous plutonic sills of gabbro and carbonated basalt as well as between basic and acid volcanics have been favourable loci for gold mineralisation.

In Gadag schist belt, shear controlled mineralisation is concentrated (1) in andesite, (2) at andesite-quartz porphyry contact and in quartz-carbonate veins filling up ductile shears.

In Chitradurga and Shimoga schist belts, besides shear controlled mineralisation in Fe enriched tholeiitic basalts and potash rich rhyolites, the most significant gold mineralisation is recorded in strata and structurally controlled banded sulphide cherts (B.I.F.) of Albama type of volcanogenic origin which are contributing large tonnage, low tenor gold ore. Gold, deposited with pyrite, pyrrhotite and arsenopyrite in banded iron formation and intercalated within volcanosedimentary sequence, is remobilised and reconcentrated by intense folding and accompanying ductile shears along limbs in quartz and quartz-carbonate veins.

The Nuggihalli schist belt representing ancient supracrustal has hosted gold mineralisation of strata bound type where the ultramafic mafic rocks of Komatiitic composition have hosted gold mineralisation along the zones of silicification and mostly gold is in free form.

2.1.2 Genetic classification of gold deposits of Karnataka

Based on the genesis, gold deposits of Karnataka are classified as follows:

Table I.

Geological Formation	Type	Host-rock	Prominent wallrock alteration and associated minerals	Example
GREENSTONE BELTS				
1. Dharwar Group	1.Syngenetic strata-bound	a. Banded iron formation		
		1. Stratiform	Arsenopyrite	**Mallappana konda** (Kolar) **Veligallu** (A.P.)
		ii) Recrystalised quartz	Chloritisation;pyrite	**Ajjanahalli** and **Nabhapur** (Chitradurga) **Chinmulgund** (Dharwar)
		b.Metachert	Biotitisation; pyrrhotite	West lodes of K.G.F; **Arikere, Jaderi, Syagatur Nayakanahalli** and **Jayamangala** blocks (North Kolar)
2.	Epigenetic vein	a.Ultramafic	Chloritisation; pyrite	**Mundys** lode of K.G.F.
		b.Metagabbro and biotitisation; pyrite	Chloritisation west lodes of Block I in and arsenopyrite	**Manigatta** and **Chigargunta** (Kolar) and **Uti** block (Hutti)
		c.Metabasalt	Chroritisation and biotitisation pyrite arsenopyrite and Scheelite	Gold-quartz lodes **(Muscoom Champion)** of K.G.F. Centinary lode **Chigargunta;Okleys and village reef** (Hutti) **Mukanagavi** (Manglur) **G.R.Halli** and **Javagondanahalli** (Chitradurga)
		d.Meta andesite	Sericitization and carbonatization; pyrite arsenopyrite and scheelite	**Champion-Hosur Yelishirur Venkatapur,** Mysore West, Middle lodes (Gadag)

Table I Contd.....

Geological Formation	Type	Host-rock	Prominent wallrock alteration and associated minerals	Example
				Kuderkonda Palavanahalli, Honnehatti Singanamane blocks(Shimoga) lodes of **Ramagiri** gold field.
		e.Acid volcanics of rhyodacite composition and quartzporphyry	Sericitization;pyrite arsenopyrite and scheelite	East lodes of **Chigargunta Maharajagadai** (Kolar) strike and middle reefs (Hutti) **Hosur block** (Gadag)
		f.Granite	-	**Maharajagadai** (Kolar)
		g.Pegmatite	-	**Manglur** west lode (Manglur)
		h.Meta-Sedimentaries	Sericitization;pyrite	**Mysore east Sangli** lodes (Gadag) **Udbal block** (Hutti)
GRANULITE BELT				
1.	Epigenetic vein	Amphibolite and biotite gneiss	Sericitization; pyrite	**Kavudahalli, Porsedyke Amble** and **Woolagiri** lodes (Mysore district)

Adapted from : Geology of the Gold deposits of India. P.S.Rao, U.S.Reddy. Geol.Sur. India, UNDP.Inter Regional Seminar on Gold Exploration and Development, 1985.

Chapter 3

ANCIENT GOLD WORKINGS

Nature hereself makes it clear that the production of gold is laborious, the gaurding of it difficult, the zest for it very great and its use balanced between pleasure and plain

- Diodorus Siculus (1st Century B.C.)

From the available Records, Bulletins, Memoirs and Reports of Mysore Geological Department (Department of Mines & Geology), Hyderabad Geological Survey (Nizam's period) and Geological Survey of India, a catalogue of ancient gold workings in Karnataka, distributed in different parts of the state has been prepared (Refer Geological map No.3.2).

From the list of ancient workings, it is evident that ancient miners have combed all the auriferous bands right from Kolar Gold Field on the east to the western ghat belt on the western margin of the craton. Since, auriferous band covering metavolcanics, meta sedimentaries, high grade rocks including granulite belt have been thoroughly searched by the ancients, such workings have served as guides for the modern gold exploration.

3.1. THE EARLY SURVEYS

The entire schist belts of Karnataka craton are dotted with ancient workings and systematic survey of these workings were attempted only after the Europeans initiations soon after the fourth Mysore War.

Notable surveys were carried out by Lt. John Warren(1802), Robert Bruce Foote(1882), Mervyn Smith(1904),Bosworth Smeeth(1889).

Outside the present Kolar Gold Field also, it was the systematic geological traverses of R.B.Foote of Geological Survey of India which brought to light many auriferous tracts of Karnataka, specially his work between 1874 and 1900 remains all time classic.

The magnitude of ancient mining has been recorded by Mervyn Smith (1892, pp.316-317).

> One of the most remarkable pieces of evidences of the nature and extent of gold mining operations in ancient India, is to be found in the numerous old workings seen in the gold districts of India. So long ago as in the times of Pliny, the mines

of gold and silver in the country of the Nareae in South India were famous. Mysore borders on the country of the Nairs of Nareae, and probably it was the gold mines or Mysore that were meant. At present, most is known of the 'old workings' of Mysore, owing to the fact of a successful gold industry under European management being established in that country. Some years ago (1881), I gave a description of the more remarkable of these ancient mines of Mysore, in a paper published in the Journal of the Society of Arts, of London. Since that time I have had an opportunity of visiting similar works in the Nizam's dominions, in Bengal and in parts of Bombay Presidency. Alluvial or drift mining, as well as reef mining, was practiced by these old workers, as is evidenced by the shafts, tunnels and open cuts still to be seen. In the Mysore mine old workings have been discovered extending as deep as 309 feet from surface. In another part of the same district, I have plumbed a shaft 186 feet deep showing 105 feet of water. That it was originally very much deeper is patent, when allowance is made for the amount of stuff that must have been washed in from the adjacent ground by the rains since the mine was abandoned.

3.1.1. The importance of ancient gold workings

The importance of ancient gold workings, specially, in deciding the future of gold companies in India, is again recalled in the mining journal, May 10, 1930, p.376:

> The period of prosperity of the Kolar Gold Field however did not set in without much misfortune and many disappointments on the part of the pioneers, several years of work and numerous reconstructions, and, as Mr. Ralph Stokes, in his "Mines and Minerals of the British Empire," pointed out, "In its early misfortunes, the Kolar gold-field stands almost unique amongst metalliferous districts of importance. On the Rand, Kalgoorlie, Rossaland, Charters Towers, Ballarat and Mount Morgan fields rich surface concentrates of gold enabled the earliest pioneers to enjoy the spell of greatest prosperity. The trouble was that the ancients had been there first, and it was necessary to go below their workings before the moderns could hope to achieve success, and the remarkable results eventually obtained were due to the pluck and perserverance of the highly practical men who became associated with the field in the early eighties, and we may reflect that if it had not been for the determination and doggedness of these men, the great wealth of these famous mines might have been lost to the world.....
>
> Had the mine then been abandoned, as desired by a number of shareholders, the Kolar Field, instead of becoming one of the world's great gold producers, would in all probability have been numbered amongst its failures....

Gadag Gold fields were brought under modern exploration based on the reports of Foote in 1874, followed by a detailed observation by Maclaren

in 1905. Similarly, in Hutti Maski schist belt which was under Nizam's Government, the officers of Hyderabad (Deccan) company established in 1886 contributed a lot to our understanding not only of the geology of Hutti Maski belt, but a great number of ancient workings also.

Capt. Leonard Munn(1936) a special officer of Hyderabad Geological Survey under Nizam of Hyderabad undertook extensive survey of Hutti Maski belt and located many ancient workings including the present Hutti Mines. In fact, the Hutti mine which is contributing a great part to the gold reserves of the country is located on an ancient mine which had reached 640 feet (195m) depth before it was systematically explored and now is acclaimed as the deepest ancient working for gold in the world.

Munn records (1936, pp.77-78):

> It has been mentioned elsewhere that many of the present exposed blue qurtz veins and stringers traversing the hornblende schists are at times auriferous, and that there is every reason to suppose that the modern observer can only report on the reefs and veins discarded by ancient miners and prospectors.
>
> The enormous number of old workings scattered all over the Maski band affords clear evidence of the fact, that at some unknown date, this country was systematically explored, prospected and mined for a very long period by some race of people highly skilled, not only in mining, but also in simple effective metallurgy. There is clear evidence not only in the Raichur Doab but all over Southern India that wherever reefs, veins or stringers of quartz occurred carrying anything over 2 to 3 dwts of gold to the ton, they did not escape attention of these early prospectors. Mostly, the depth to which mining was carried was limited by water. The extreme hardness of the rock in the footwall and hanging wall of the Wandalli reef, which even restricted the monthly progress of European Miners working with modern rock drills, did not baffle them.

The importance of ancient workings is further highlighted by Malcom Maclaren, 1905 (quoted by Munn, 1936, p.81):

> Turning now to the modern history of the gold workings, we find it to date from 1886 and to be indeed a portion of the history of the Hyderabad (Deccan) Company. This company was formed in August of that year to exploit the mineral resources of the Nizam's Dominions. At that time there was no positive evidence

of the existence of gold within the concession, but shortly after the formation of the company a discovery was reported by a Police Inspector in the employ of the Nizam. In January, 1887, Mr. T.W.H.Hughes, then Deputy Superintendent, Geological Survey of India, was with the consent of the Government, engaged by the company to superintend prospecting operations. By April, he had visited the site of the reported discovery from where loose quartz had assayed one dwt. per ton, and has reported that there were no gold bearing strata in that place, but he had nevertheless discovered active prospecting in that direction. Actual prospecting was commenced in 1887. The first workings opened up were those of Budhni (Boodinni) in January of 1888 and by June active prospecting work was in progress, also at Tupdur (Toopadoor), Chick-Hesrur (Hesseroor), Topaldoddi and Wandalli and altogether 300 old workings had by that time been discovered.

The Champion reef of Kolar Gold Field which is located right over the old working has been mined by the ancients which could not be bottomed during subsequent exploration at a depth of 95 feet. Similarly, the Mysore Gold company which operated the Mysore mine in K.G.F. intersected the old working in the shafts which continued beyond 300 feet also.

The nature, extent of workings and the skill employed for developing the ancient mines is summarised by Smeeth and Sampath Iyengar (1916, p.4-5):

> Gold mining is by no means a new industry in Mysore. Hundreds of old workings have been found and bear witness to a widely extended industry in ancient time. There is little historical or traditional information about these workings or the people who made them. Doubtless, some are very ancient while others are no great antiquity and the rate of gold production must have been very small. The total amount of gold obtained was no doubt considerable but even this was in all probability but a fraction of the amount since obtained from the Kolar mines and is unlikely to have exceeded a few million pounds sterling or a few crores of rupees... many old workings still remain as large open pits or as irregular adits, tunnels or burrows. Some have been more or less filled in by natural collapse or by washing in of debris, soil etc. and in many cases, the filling has been so complete that little or no indication of old working remains.

It is evident from the above descriptions that almost all the auriferous tracts of Karnataka are invariably dotted by chains of ancient workings.

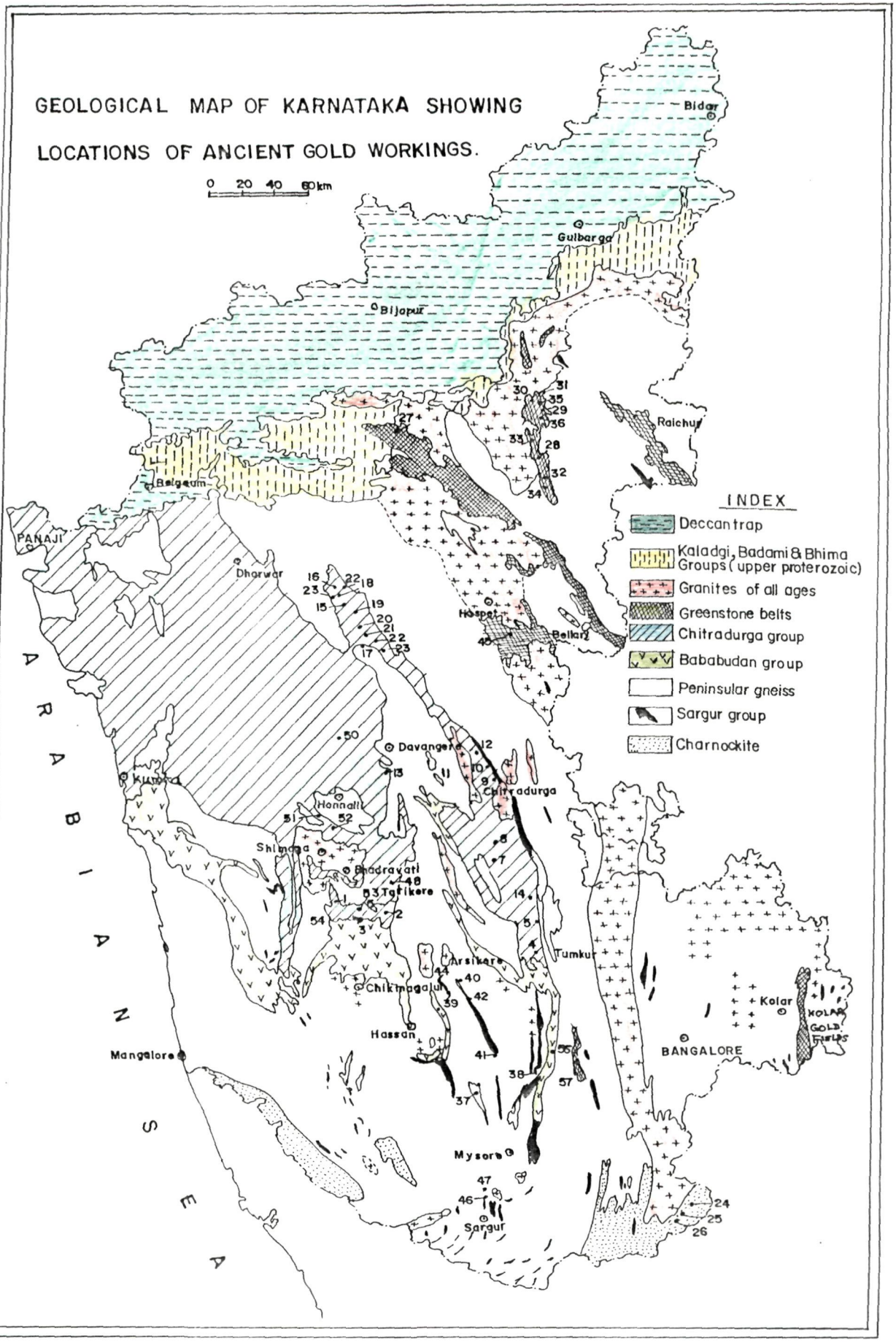

GEOLOGICAL MAP OF KARNATAKA SHOWING
LOCATIONS OF ANCIENT GOLD WORKINGS.
0 20 40 60km
INDEX
Deccan trap
Kaladgi, Badami & Bhima Groups (upper proterozoic)
Granites of all ages
Greenstone belts
Chitradurga group
Bababudan group
Peninsular gneiss
Sargur group
Charnockite
Bidar
Gulbarga
Bijapur
Raichur
Belgaum
PANAJI
Dharwar
Hospet
Bellary
Davangere
Chitradurga
Kumta
Honnalli
Shimoga
Bhadravati
Tarikere
Chikmagalur
Chiksikare
Tumkur
Kolar
KOLAR GOLD FIELDS
BANGALORE
Hassan
Mangalore
Mysore
Sargur
ARABIAN SEA

Fig 32

3.1.2. Definition of 'old' and 'ancient' workings

It is necessary to make distinction between 'ancient' workings and 'old' workings, though most of the earlier literature speak one as synonym to other. For instance the European prospectors have clearly differentiated the two. In Western Europe, where written records began under the Roman empire things are 'ancient' if they are more than 2000 years old. In America, however, Columbus provides the boundary between ancient and modern (More, 1974).

In India, the dividing line between the 'ancient' and 'old', though not defined, is generally taken as prechristian and post christian era respectively as far as mining is concerned. Sometime the term 'old workings' is applied to the prospective pits belonging to the modern historical period also.

3.2. DISTRIBUTION AND STATUS OF ANCIENT WORKINGS FOR GOLD IN KARNATAKA

(Location as shown in the Fig.3.2)

Bababudan Schist Belt

Sl.No. 1	a.	Locality	**Jalagargundi** 13°41':75°37' Chikmagalur district.
	b.	Nature of ancient working/Geology	Old working are located in talc chlorite schist on the southern end of Shimoga belt Mineralisation is localised in quartz chlorite carbonate schist with pyrite
	c.	Development/Gold value	Two shafts were sunk by Shimoga Gold Fields Ltd. during 1907-1909. Gold values varied from 6.5 to 24 g/t.
	d.	Status	Large part is now submerged under Bhadra Reservoir.
Sl.No. 2	a.	Locality	**Nandi** 13°38' :75°55, Chikmagalur
	b.	Nature of ancient working/Geology	Numerous old workings are found about 2.5 km. S.W. of Nandi. Old workings are also seen 4 km. S.W. of Lakkavalli. Quartz vein cutting talc

			chlorite schist carried gold. Reported by Primrose (1898)
	c.	Development/Gold value	No further work
	d.	Status	G.S.I. has carried out sampling
Sl.No.3	a.	Locality	**Siddarahalli** :13°43':75°46' Chikmagalur district.
	b.	Nature of ancient working/Geology	About 6 km. W.S.W. of Tarikere few old working are located in Siddarahalli area in Quartzite within chlorite schist.
	c.	Development/Gold value	Shimoga Gold Fields Ltd. developed the mine by sinking adits and shafts. Gold value upto 20 g/t has been reported.
	d.	Status	G.S.I. has carried out preliminary exploration

Chitradurga Schist Belt

Sl.No.4	a	Locality	**Ajjanahalli** 13°45':76°44' Tumkur district. Old workings are located in B.I.F. Numerous pounding stones are recovered. **(Plate 1-7)**
	b.	Nature of ancient working/Geology	B.I.F. associated with meta sedimentaries and meta volcanics is mineralised - shear controlled syn and epigenetic.
	c.	Development/Gold value	Nandydroog Co. Ltd. worked the deposit between 1907-1909. 4 adits driven. 3.8 to 11 g/t reported.
	d.	Status	Detailed exploration carried out by G.S.I. and presently prospected by H.G.M.L.
Sl.No.5	a.	Locality	**Anesidri** : 13°57':76°46' Chitradurga district
	b.	Nature of ancient working/Geology	Old workings are located in cultivated land in sheared hornblende schist traversed by quartz vein and pyrite-arsenopyrite association is seen.
	c.	Development/Gold value	Indian Mine Devt. Syndicate sunk 3 shafts upto 30m. depth during 1907-1908. Drives have analysed 27.22 to 33.6 g/t.
	d.	Status	Explored by G.S.I. during 1985-87
Sl.No.6	a.	Locality	**Bellara** 13°35' :76°35' Tumkur District.
	b.	Nature of ancient working/Geology	Two old workings on Bellara Reef and a number of old workings now seen only as depression on tank reef. Mineralisaztion confined to shear zones in metavolcanics and meta sedimentaries. Reported by Sambasiva Iyer(1900) **(Plates 8-9)**.

	c.	Development/Gold value	Ancient mine prospected by Indian Mines Development Syndicate between 1902-1905, developed upto 600 m. length and 122 m. depth in tank reef, and 135 m. length 70.10 m. depth on Bellara reef. Dept.of Mines and Geology mined in 1944 and produced 62 kg. of refined gold crushing 19,966 tonnes Blocked out reserve 50,000 tonnes at 3.5 g/t.
	d.	Status	G.S.I. has carried out investigation.
Sl.NO.7	a.	Locality	**Bodimaradi** : 13°45'40" :76°26'50" Chitradurga District.
	b.	Nature of ancient working/Geology	Deep, narrow workings are located on the flanks of Iplara hills. Gold occurs in stringes of quartz traversing manganiferous chert. Reported by Sambasiva Iyer.
	c.	Development/Gold value	Winze sunk by Indian Mines Devt. Syndicate for 30 m. depths. Limonitic Capping anlaysed 4.6 to 6.2 g/t.
	d.	Status	Investigated by G.S.I.
Sl.No.8	a.	Locality	**Dindavara** : 13°48' : 76°39" Chitradurga District.
	b.	Nature of ancient working/Geology	Prospecting carried out on the ridge south of Dindavara in ferruginous quartzite traversed by quartz vein. Reported by Bosworth Smith (1907)
	c.	Development/Gold value	No further exploration work since gold incidence is restricted to the weathered and oxidised zone.
	d.	Status	Preliminary investigation is carried out by G.S.I.
Sl.No.9	a.	Locality	**Gonur** : 14°46' : 76°26' Chitradurga District.
	b.	Nature of ancient working/Geology	Several ancient workings are located in meta-arkose quartzite -chlorite schist. Reported by Bruce Foote.
	c.	Development/Gold value	Prospected by Cole 1890, Sambasiva Iyer 1897, crushing and panning by Iyer indicated incidence of gold in 1906. M.G.D. carried out prospecting and subsequently prospected by Madras-Mysore Mining Syndicate followed by Drilling. No commercial mineralisation is encountered.
	d.	status	G.S.I. has carried out geochemical exploration.

Sl. No.10	a.	Locality	**Guddada Rangavvana halli.** 14°17'20": 76°23'40" Chitradurga district.
	b.	Nature of ancient working/Geology	A series of old workings located in meta-volcanics comprising massive, schistose and carbonated metabasalt and acid volcanics. Reported by Foote, 1888. Auriferous quartz is carry sulphides. High proportion of silver is associated.
	c.	Development/Gold value	Developed by G.S.I. by detailed drilling investigation.
	c.	Status	Being mined by H.G.M.L. Co. **(Plate 10-11)**
Sl.NO.11	a.	Locality	**Halekal** : 14°27 : 76°'12' Chitradurga district
	b.	Nature of ancient working/Geology	Workings are located in micaceous and chloritic schist associated with conglomerate and quartzite. Reported by Foote (1900)
	c.	Development/Gold value	Prospected by Slater between 1907 and 1909 and subsequently Coleridge.
	d.	Status	No further work
Sl.No.12	a.	Locality	**Honnemaradi** : 14°28' : 76°25' Chitradurga district
	b.	Nature of ancient working/Geology	Stream indicated placer gold
	c.	Development/Gold value	Prospected by Sampat Iyengar 1905 and Madras-Mysore Mining Syndicate 1960.
	d.	Status	G.S.I. has carried out preliminary investigation.
Sl.No.13	a.	Locality	**Malebennur** :14°21':75°48' Chitradurga district.
	b.	Nature of ancient working/Geology	Stream sediment indicate gold on the slope of the ferruginous quartzite ridge associated with chlorite schist, lime stone traversed by quartz. Reported by Foote, 1888
	c.	Development/Gold value	— Nil —
	d.	Status	Not prospected by any agency still.
Sl.No.14	a.	Locality	**Nalbaigudda** 13°50' :76°39' Chitradurga district
	b.	Nature of ancient working/Geology	Several old workings in crystalline lime-stone siliceous grit. Old workings have reached upto 45 m. depth. Reported by Sambasiva Iyer (1900).
	c.	Development/Gold value	— Nil —
	d.	Status	No further work.

Gadag Schist belt

Sl.No.15.	a.	Locality	**Attikatti** 15°16'15" : 75°37'15" Dharwar district
	b.	Nature of ancient working/Geology	Numerous old workings are located and this forms the southern extension of Kabuliyat Katti reefs. These are the earliest to be developed in Gadag Gold Field.
	c.	Development/Gold value	Mineralisation is in meta andesite. Developed by Dharwar Gold Mines Ltd. and the Central Reef developed over a length of 120.4 m. value reported - 6.4 g/t
	d.	Status	Detailed work is carried out by G.S.I.
Sl.No.16	a.	Locality	**Hosur-Champion Mines** 15°10'-15°25' 76°25' - 76°43' Dharwar district
	b.	Nature of ancient working/Geology	Extensive old workings are located and are mostly covered by cultivation. Main mines are situated 6 km. west of Kabuliyatkatti village. Mineralization is shear controlled and is in meta andesite. Extensive Silicification, chloritisation with veins of quartz and carbonate associated with pyrite and arsenopyrite. Gold is in native form. Reported by Foote, 1874.
	c.	Development/Gold value	Worked by Dharwar Champion Reef Gold Mining (India) Ltd. and subsequently by M/S Oakley Duncon & CO., Ltd. Hosur Mine Reef consists of 3 shafts and six levels and the maximum depth is 182.90 m.
	d.	Status	G.S.I. has carried out detailed exploration. **(Plate 12)**
Sl.No.17	a.	Locality	**Jelligeri** 15°12' : 75°39' Dharwar district
	b.	Nature of ancient working/Geology	workings are located about 1.6km. north west of Jelligeri along the reef on the western slope of the hillock 2664.-2703 where 6 - 8 feet diameter 15-25 feet deep workings filled with debris in ferruginous argillaceous rocks are seen. Reported by Foote (1873)
	c.	Development/Gold value	Dharwar Gold Mines Ltd. worked between 1909-11 and the work was suspended.
	d.	Status	Prospected by G.S.I.
Sl.No.18	a.	Locality	**Kabuliyatkatti** 15°17'45": 75°38'00" Dharwar district
	b.	Nature of ancient working/Geology	All the 3 reefs south of the village are worked by the ancients. Mineralisation is

			in sheared carbonated and silicified meta diorite with sulphide association. Old working has reached a depth of 300 feet. Reported by Foote, 1874.
	c.	Development/Gold value	Worked by Dharwar Gold mining Ltd. and Dharwar Gold Reef Co., Ltd. by sinking 5 shafts. Central reef developed over a strike length of 1012 m. and has yielded 527 kg. gold after crushing 46,000 tons material.
	d.	Status	Detailed exploration carried by G.S.I.
Sl.No.19	a.	Locality	**Mysore Mines,** 15°10'-15°25': 76°25'-76°43' Dharwar district.
	b.	Nature of ancient working/Geology	These mines are located south of Attikatti mine. Mineralisation is in meta andesite associated with sulphides.
	c.	Development/Gold value	3 main reefs developed by sinking 4 shafts and 3 adits. Middle reef developed upto 500 feet level. West reef 300 feet level. East reef 500 feet level.
	d.	Status	Explored by John Taylors and Co. followed by detailed work by G.S.I.
Sl.No.20	a.	Locality	**Papanashini Doni Nabhapur Venkatapura** 15°15'00"-15°18'00" 75°35'00"-75°41'00"
	b.	Nature of ancient	A continuous chain of old workings exist. Geology is amphibolite with a few narrow bands of calc silicates - impure banded dolomite, banded magnetite chert and vein quartz and sheared controlled; quartz vein is mineralised and is associated with sulphides. Reported by Foote (1874)
	c.	Development/Gold value	No further work
	d.	Status	Under investigation by G.S.I.
Sl.No.21	a.	Locality	**Sangli Mines** 15°10'00'-75°44'00" Dharwar district
	b.	Nature of ancient working/Geology	Located south of Mysore mine. 22 workings, 18-25 feet deep near Jalagaragudda have been discovered. Gold mineralisation is confined to three parallel shear zones at the contact of meta sedimentaries and meta volcanics. Reported by Aytoun - 1852
	c.	Development/Gold value	Worked by Sangli Gold mining Co., by sinking 2 shafts upto a maximum depth of 152.4 m.

	d.	Status	Explored by G.S.I. Sangli north is under development by M.E.C.L.
Sl.No.22	a.	Locality	**Sankadodak** 15°11' :75°38' Dharwar district
	b.	Nature of ancient working/Geology	Old workings are present and the mineralisation is in highly sheared, silicified, brecciated carbonatised argillite, arenite rock
	c.	Development/Gold value	No subsequent development
	d.	Status	Prospected by G.S.I.
Sl.No.23	a.	Locality	**Yelsirur** 15°16'15":75°36'00" **Dharwar** District.
	b.	Nature of ancient working/Geology	Ancient workings are scattered over a length of 8km. and over a width of 80m. mostly filled and appear like depressions, but are in the form of inclined shafts, inter connected with a probable depth extension upto 50m. Mineralisation is in meta andesite with tuff.
	c.	Development/Gold value	Worked by Sangli Mining Co., Ltd. in 1903 excavating 597 m. by mining.
	d.	Status	Detailed prospecting is by G.S.I.

Granulite Belt

Sl.No.24	a.	Locality	**Hadabanatta** 11°57':77°21' Mysore district.
	b.	Nature of ancient working/Geology	Workings are located 3 km. north of Porse dike and the reefs are its extensions. Old workings are 6-8 m deep. Extensive old workings are also seen north west of Hosur and Dinhalli.
	c.	Development/Gold value	Lode is associated with sulphides and stray values of 3.4 to 8.5 g/t is recorded.
	d.	Status	No further work
Sl.No.25	a.	Locality	**Kavudalli-Doddalatur** 12°04':77°26', 12°02' :77°25' Mysore district
	b.	Nature of ancient working/Geology	Old workings in Kavudalli are located in charnockite. Reported by Middlemiss (Quoted by Oldham-1896)
	c.	Development/Gold value	Lode carrying 1.5-3.g/t has been reported. The deposit was being worked in 1896.
	d.	Status	No further work
Sl.No.26	a.	Locality	**Porse Dike** 11°53':77°21' Mysore district
	b.	Nature of ancient working/Geology	About 3 km. N.E. of Porse-gondana Palya, workings are located in the quartz veins associated with charnockite.

	c.	Development/Gold value	Worked by Randalph Morris of Attikan estate by sinking 3 vertical shafts to a maximum depth of 30 m. but no reef has been encountered.
	d.	Status	No further work

Hungund Schist belt

Sl.No.27	a.	Locality	**Ilhal** 15°57':75°38' Bijapur district
	b.	Nature of ancient working/Geology	3 km. west of Ilhal old working is located in hornblende schist. Reported by Venkoba Rao (Quoted by West 1960)
	c.	Development/Gold value	No work has been done
	d.	Status	

Hutti Maski schist belt

Sl.No.28	a.	Locality	**Budini** 16°11'34" - 76°48'20" Raichur District.
	b.	Nature of ancient working/Geology	Ancient workings are distributed over a length of 1100 m. on N.S. trending ridge. Many workings are shallow and partially filled with rubbles.Mineralisation is confined to a highly sheared chlorite schist with quartz ankerite veins. Reported by the Hyderabad (Deccan) Co.
	c.	Development/Gold value	Development by sinking shafts through large ancient workings. 2 lodes are developed. Main and Mopla lodes. 75,000 tonnes of ore milled for a return of 3.2 g/t.
	d.	Status	G.S.I. has carried out detailed exploration. M.E.C.L. has completed development on Moplalode. **(Plate 13)**
Sl.No.29	a.	Locality	**Chinchergi** 16°09'45" :76°47'45" Raichur District
	b.	Nature of ancient working/Geology	Workings are located east of Wandalli in amphibolites. Lodes are confined to the late stage F.1 deformation affected by F.2. Described by John Taylor & sons.
	c.	Development/Gold value	Between 1887 and 1900 Hyderabad (Deccan) Co.,worked this mine.
	d.	Status	G.S.I. has carried out detailed exploration.
Sl.No.30	a.	Locality	**Hutti Mine** 16°11':76°39' Raichur district
	b.	Nature of ancient working/Geology	Developed on the deepest ancient mine in the world intersected at 190m. Mainly schistose amphibolite with acid volcanics. Gold occurs in the native state

			with an average silver content of 8% Reported by Hyderabad(Deccan) Co., - 1889.
	c.	Development/Gold value	Hyderabad (Deccan)Co. worked this ancient mine in 1889, Hutti (Nizam's) Gold Mine Co., explored in 1901 developing 1140 m. in main reef, mine closed in 1920 and reopened in 1937 by Hyderabad Gold Mining Co., until 1956. subsequently on reorganization was transferred to Karnataka and now is worked by Hutti Gold Mining Co., From 1948 - 1989 a total of 32 tons of gold has been produced from 5 million tonnes of ore.
	d.	Status	Highest gold producing mine in India at present, after decline of production in K.G.F.
Sl.No.31	a.	Locality	**Kadoni** 16°14'20":76°41'40" Raichur district
	b.	Nature or ancient working/Geology	Located 5 km. N.E. of Hutti old workings and Kadoni old working are aligned N.W.-S.E. have reached upto 140 feet in meta basalt. Most old workings are covered by block cotton soil. Geophysical work carried out by Hyderabad Gold Development Organisation has brought to light many concealed old workings.
	c.	Development/Gold value	2 shafts 400 m. apart reaching a depth of 606 m. and 65.35 m. were sunk by Hyderabad Gold development Co., About 800 tons of 14.4 g/t had been recovered because the lode was impersistant mine was closed in 1898.
	d.	Status	G.S.I. has carried out detailed exploration.
Sl.No.32	a.	Locality	**Sanbal** : 16°01' : 76°44' Raichur District
	b.	Nature of ancient working/Geology	Old workings are located mainly in Chlorite schist, traversed by quartz vein and are lying adjacent to Maski workings. Reported by Hyderabad (Deccan) Co. and Deccan Gold Fields Devt. Co., Ltd.
	c.	Development/gold value	Shafts sinking in ancient workings upto 28 m. Reef analysed 10.4 g/t
	d.	Status	Subsequent work has been carried out by G.S.I.
Sl.No.33	a.	Locality	**Topaldoddi** : 16°10' : 76°51' Raichur district

	b.	Nature of ancient working/Geology	6.5 km. S.E. of Wandalli village. Ancient workings running E.W. and upto 200 feet depth have been recorded in sheared schistose meta basalt associated with quartz carbonate veins. Reported by Bose Worth Smith, 1898
	c.	Development/gold value	3 veins have been worked by shaft sinking by Hyderabad (Deccan) Co., and 66 kg of gold has been produced.
	d.	Status	G.S.I. has delineated additional 5 lodes
Sl.No.34	a.	Locality	**Udbal** : 15°57' : 76°40' Raichur district
	b.	Nature of ancient working/Geology	Southern continuation of Ramaldinni Kadabur ancient workings. Workings are 500m. south of Udbal village. Old pits and dumps with fragments of blue quartz in chlorite schist. Kadabur old workings were reported by Kight, Hoolour workings are reported by Aubrey.
	c.	Development/gold value	Deccan Gold Fields Co., Ltd., developed by sinking shaft upto 34 m. followed by Oorgam Gold Mining Co.,
	d.	Status	No further work due to water problem.
Sl.No.35	a.	Locality	**Uti** : 16°16' : 76°51' Raichur district
	b.	Nature of ancient working/Geology	Several hundreds of old workings have been traced upto Gondal village. Silicified and carbonatised mafic and oxide rocks host gold mineralisation in quartz vein associated with sulphides.
	c.	Development/gold value	Deccan Gold Fields Devt. Co., Ltd., in 1893 developed the central shafts and big pit, Hyderabad Gold Devt. Orgn. worked the mine between 1940-41. Quartz fragment from old workings returned 8 g/t. Work suspended due to 2nd world war.
	d.	Status	M.E.C.L. is developing the mine.
Sl.No.36	a.	Locality	**Wandalli** : 16°13'45" : 76°44'30" Raichur district
	b.	Nature of ancient working/Geology	12 km. east of Hutti mine. Ancient workings upto 120 m. depth are reported. Mineralisation is in meta volcanics traversed by quartz vein associated with sulphides. North Wandalli area prospected during 1940-41 revealed complex system of old working. Some are 30 m. long 7 m. wide 3 m. deep. Reported by Deccan Gold Fields Devt. Co.,
	c.	Development/gold value	Wandalli Co., operated the mine between 1896-1901 producing 465 kg. of gold. Work ceased in 1901. Subsequently

			M/S John Taylor & Sons carried out prospecting in 1940-41. Work was closed due to 2nd world war.
	d.	Status	Presently developed by M.E.C.L.

Krishnarajpet schist belt

Sl.No.37	a	Locality	**Bellibetta** 13°37' : 76°27' Mandya district
	b.	Nature of ancient working/Geology	Nearly 30 ancient workings are located on the synformal closure of Bellibetta immediately west of Katraghatta on the northern slope, in talc chlorite actinolite schist with quartz vein. Reported by Foote (1888)
	c.	Development/gold value	New Kempinkote Co.,Ltd., developed the working between 1901-1902 by sinking shafts. The value of gold is reported to be 1 dwt per tonne.
	d.	Status	G.S.I. has carried out preliminary geo-chemical work.

Nagamangala schist belt

Sl.No.38	a.	Locality	**Nagamangala, Honnebetta, Haltibetta, Hulmandi betta**:12°49' :76°45' Mandya district
	b.	Nature of ancient working/Geology	Honnabetta working is 3 km. south west of Nagamangala town and is located in talc tremolite schist traversed by quartz vein carrying pyrite. It is a recent working. Haltibetta workings are located in a narrow patch of ultramafics (Mayasandra belt) Shallow working with grey quartz reef. Hulumandibetta is 3 km. North of Honnabetta in the same strike continuity.
	c.	Development/gold value	It was opened during Foote's visit in 1888. Gold was reported from the stream draining N.E. side of Honnabetta hill. Working is of shallow nature. Recent shaft is located in the talc tremolite schist, traversed by quartz vein carrying sulphides. No visible gold.
	d.	Status	No further work. G.S.I. has carried out preliminary geochemical work.

Nuggihalli schist belt

Sl.No.39	a.	Locality	**Gollarahalli** : 13°10' : 76°20' Hassan district
	b.	Nature of ancient working/Geology	A series of old workings in meta ultramafics are located about 2 km. west

			of Gollarahalli. They follow synformal closure. Reported by Foote (1889).
	c.	Development/gold value	The hanging wall of pyroxenite has been scooped out
	d.	Status	G.S.I. has carried out detailed work.
Sl.No.40	a.	Locality	**Karadihalli** : 13°29' : 76°10' Hassan District
	b.	Nature of ancient working/Geology	Old working is located 16 km. south of Karadihalli within hornblende and chlorite schist. Reported by Foote (1889)
	c.	Development/gold value	Samples from the old workings has good value but quartz reef has not been traced.
	d.	Status	No further work
Sl.No.41	a.	Locality	**Kempinkote** : 12°54' : 76°31' Hassan district
	b.	Nature of ancient working/Geology	Large old working is located in talc tremolite schist interbanded with hornblende schist in the southern most part of the Nuggihalli belt. Silicified mafic ultramafic rock is mineralised. Reported by Foote (1889)
	c.	Development/gold value	Kempinkote Gold Fields Ltd., worked the mine between 1893 and 1896 by sinking 2 shafts to a maximum depth of 150 m. and driving at 2 levels. Maximum gold value reported is 4.6 g/t
	d.	Status	Dewatering and sampling work has been carried out by M.E.C.L. and drilling exploration by G.S.I. also by M.E.C.L.
Sl.No.42	a.	Locality	**Mallenahalli** : 13°10' : 76°27' Hassan district
	b.	Nature of ancient working/Geology	Auriferous quartz is reported in the old workings located in hornblende schist near Mallenahalli. Reported by Foote (1889)
	c.	Development/gold value	Sampling of the ancient working has returned moderate gold value
	d.	Status	No further work
Sl.No.43	a.	Locality	**Vittalapura** Hassan district
	b.	Nature of ancient working/Geology	Old working is located 3 km. south of Yelwari extending over 500 m. strike length in mafic ultramafic rock.
	c.	Development/gold value	Recently located by G.S.I.
	d.	Status	G.S.I. has done preliminary work

Sl.No.44	a.	Locality	**Yelwari** : 13°16': 76°14' Hassan district
	b.	Nature of ancient working/Geology	Old workings are located east of Harnalli and extend over 300 m. length and 15 m. width. Located in mafic ultramafic rocks
	c.	Development/gold value	Mysore Harnalli Gold. C., carried out prospecting and recovered 780 grams of gold
	d.	Status	No further work. G.S.I. has carried out preliminary drilling investigations.

Sandur schist belt

Sl.NO.45	a.	Locality	**Ettinahatti** (Taranagar) 15°08':76°37' Bellary district
	b.	Nature of ancient working/Geology	Ancient workings are found 3 km. S.S.E. of Ettinahatti, in massive schistose volcanic rock traversed by quartz vein of Nandihalli formation. Gold mineralisation is associated with sulphides. Old workings are spread over 390 m. in length. Reported by Venkataram (Quoted by West, 1948)
	c.	Development/gold value	Ancient works have been developed by 3 drives - 2 m. long stoped over a width of 1.1 m. in acid volcanics. Samples analysed by John Taylor & Sons *in 1967* showed gold values ranging from 2.25 to 45 g/t.
	d.	Status	Preliminary work carried out by G.S.I

Sargur schist belt

Sl.No.46	a.	Locality	**Amble** 12°03' : 76°35' Mysore district
	b.	Nature of ancient working/Geology	Workings are located in massive amphibolite associated with calc silicate rocks traversed by pegmatite and auriferous quartz vein.
	c.	Development/gold value	Between 1882-1930 The Woolgiri Co., Ltd., The Amble Syndicate, New Kempinkote Gold Fields Ltd., The Nanjangud Gold Field LTd., and the Eastern Devt. Corpn. Ltd., worked this mine to a depth of 60 m. Occasional gold values upto 7.5 g/t has been reported.
	d.	Status	No further work
Sl.NO.47	a.	Locality	**Woolgiri** 12°04' : 76°40' Mysore district
	b.	Nature of ancient working/Geology	Old workings are located north of Amble workings in hornblende schist and gold is associated with pyrite. P. Bose Worth Smith reports "By far the largest old working is that on which the modern

			mine itself has been sunk having a length of 248 ft. breadth of 90 ft. and a depth of 35 feet.
	c.	Development/gold value	Worked by M/S Nanjangud Gold Field Ltd., driving levels at 30 & 40 m. in a shaft about 30 m deep. Average 5 g/t recovered and produced 2.0 kg. of gold in 1906 by the Dept. of Mines & Geology and the mine was closed in 1913.
	d.	Status	No further work

Shimoga schist belt

Sl.No.48	a.	Locality	**Ajjampura** 13°43' : 76°04' Chikmagalur district
	b.	Nature of ancient working/Geology	2 Old workings are located in Honnadonna, Hakkidonna. They are located in chloritic and feldspathic quartz ite associated with champion gneiss. Reported by Sambasiva Iyer (1897)
	c.	Development/gold value	Kadur Mysore Gold Co., prospected by driving adits and shafts upto 90.8 m. The highest gold value reported is 3.6 g/t.
	d.	Status	Preliminary Survey carried out by G.S.I.
Sl.No.49	a.	Locality	**Bukkambudi** 13°49' : 75°59' Chikmagalur district
	b.	Nature of ancient working/Geology	Old workings in the form of inclines and shafts, tunnels, burrows in talc chlorite schist with quartz and calcite.
	c.	Development/gold value	Prospecting work carried out by Dept. of Mines and Geology. Lode carried sulphides of lead and zinc with little silver but restricted to oxidation zone only
	d.	Status	G.S.I. has carried out preliminary Survey
Sl.No.50	a.	Locality	**Chinmalgund** 14°24' : 75°35' Dharwar district
	b.	Nature of ancient working/Geology	Old workings in the form of inclines, shafts, pits distributed over 3 km. strike length. Auriferous quartz reef occurs at the contact of B.I.F. with sericite phyllite. Ancient workings have reached upto 40 m depth. Sulphide rich B.I.F. is fractured, silicified with partings of schist and tuff and is mineralised.
	c.	Development/gold value	Sampling carried out by John Taylor & Sons, analysed 3.6 g/t.
	d.	Status	Detailed exploration carried out by G.S.I.

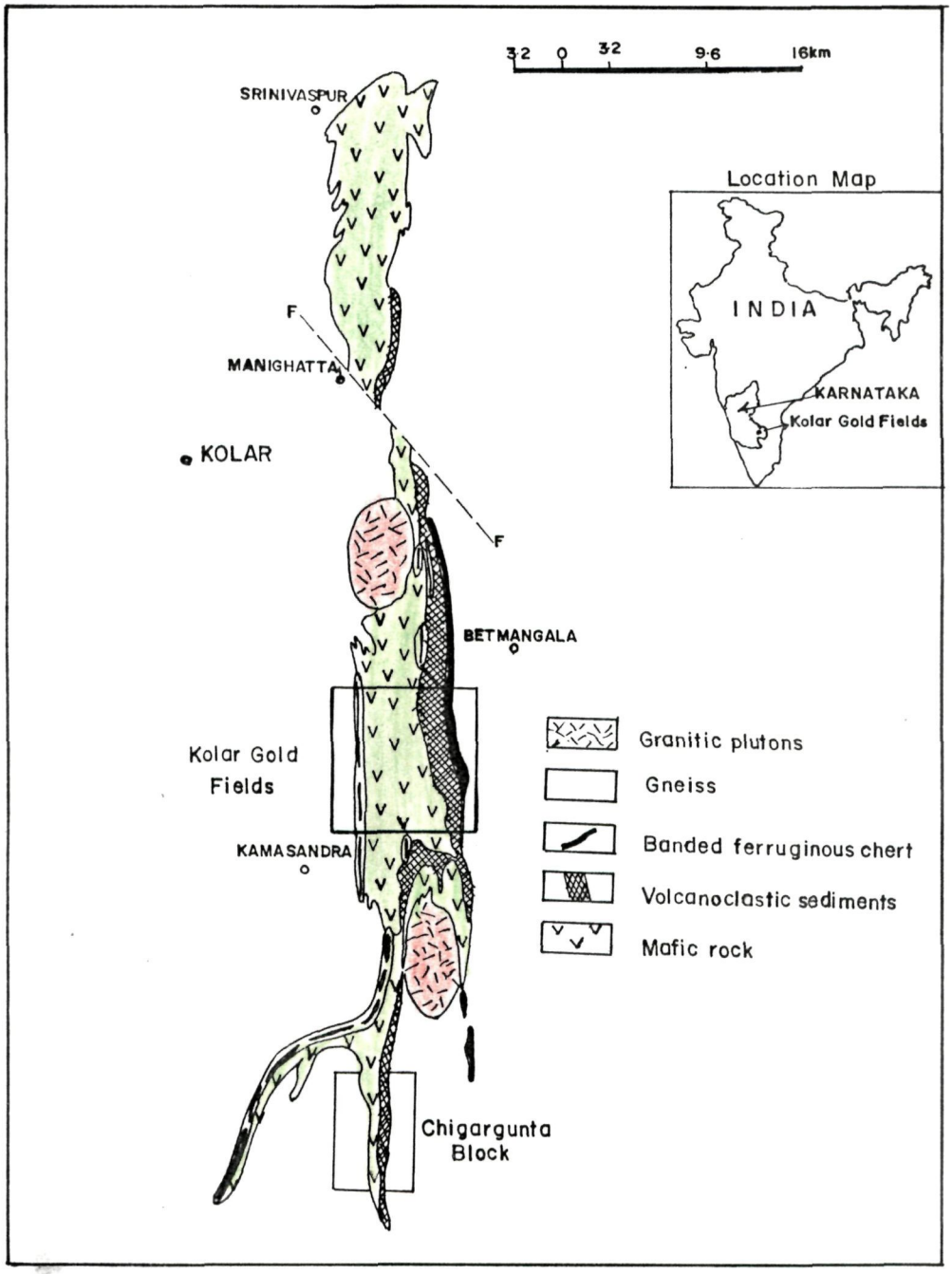
Sl.No.51	a.	Locality	**Honnali Fields, Kudrekonda** 14°08' :75°33' Shimoga district
	b.	Nature of ancient working/Geology	There are a number of old workings which have been worked as early as 1880, by the European companies. The area is comprised of interlayered meta sedimentary sequence and intermediate to acid volcanics. Gold mineralisation occurs in sheared meta andesite. Reported by Foote in 1888
	c.	Development/gold value	In 1907 from Kudrekonda area, the largest nugget weighing 139.9 grams of gold and the richest lump of float quartz weighing 6.7 kg. containing 1.39 kg. of gold was discovered. Honnali Gold Mining Co., prospected the area by sinking 5 shafts recovering 16.4 kg. of gold by crushing. Due to erratic behaviour of the lode the work was suspended.
	d.	Status	G.S.I. has carried out preliminary investigations.
Sl.No.52	a.	Locality	**Palavanahalli** 14°06' : 75°35' Shimoga district
	b.	Nature of ancient working/Geology	Workings are located 6.5 km. S.E. of Honnali Mines in quartz vein.
	c.	Development/gold value	Palavanahalli Gold Mining Co., carried out prospecting and later between 1940 and 42 the Dept. of Mines and Geology continued investigation but could not cope up with water problem.
	d.	Status	No further work. Preliminary work carried out by G.S.I.
Sl.No.53	a.	Locality	**Honnehatti** : 13°46' : 75°42' Shimoga district.
	b.	Nature of ancient working/Geology	Several old workings are located 8 km. S.W.of Badravathi on the Honnegudda hill. Gold mineralisation is reported in quartz calcite vein traversing meta andesite.
	c.	Development/gold value	Prospected by Mysore Nagar Gold Mining Co., in 1887 by sinking adits. Assay values varied from 3.7 g to 12.4 g/t. The narrow width of the lode made working uneconomical.
	d.	Status	G.S.I. has carried out preliminary work
Sl.No.54	a.	Locality	**Tambadi Halli** 13°45' :75°38' Shimoga district

	b.	Nature of ancient working/Geology	Forms parts of the Honnali Fields and several old workings are located in the forest area around Tambadihalli and Singanmane. Stringes and lenses of quartz host gold mineralisation.
	c.	Development/gold value	Shimoga Gold Fields Ltd., prospected the area during 1906 -1908 by sinking shaft and drives. Lode is impersistant.
	d.	Status	Under investigation by G.S.I.

Yediyur Karighatta belt

Sl.No.55	a.	Locality	**Hunjanakere** 12°20' : 76°48' Mandya district
	b.	Nature of ancient working/Geology	Old workings are located on the southern end of Karighatta belt in quartz veins traversing amphibolite associated with meta sedimentaries.
	c.	Development/gold value	Prospecting carried out by the Dept. of Mines & Geology by shaft sinking and driving. No lode could be located.
	d.	Status	G.S.I. has carried out preliminary investigation.
Sl.No.56	a.	Locality	**Kalinganahalli**:12°58' : 76°26' Mandya district
	b.	Nature of ancient working/Geology	South of Yediyur bridge near Kalingana halli, washings for gold was reported with several dumps raised by the ancient miners. Reported by Ogden (quoted by Foote 1888)
	c.	Development/gold value	Prospected by G.S.I. and incidence of gold is reported from ferruginous quartzite.
	d.	Status	Sampling of G.S.I. has indicated low concentration of gold in sheared ferruginous quartzite.
Sl.No.57	a.	Locality	**Karimuddanahalli** :12°12' : 76°26' Mandya district
	b.	Nature of ancient working/Geology	Old workings are located on a ridge east of Karimuddanahalli in hornblende schist with quartz reefs. Reported by Foote (1889)
	c.	Development/gold value	Washing by Foote did not reveal any gold
	d.	Status	No further work

(The list does not include the ancient workings from Kolar gold field since many of the workings have been developed into mines. Altogether there exist more than 100 locations in Karnataka alone)



GEOLOGICAL SKETCH MAP OF KOLAR GREENSTONE BELT.
(After Viswanatha and Ramakrishna. 1981)
Fig 3·2·1

3.2.1 Kolar gold field

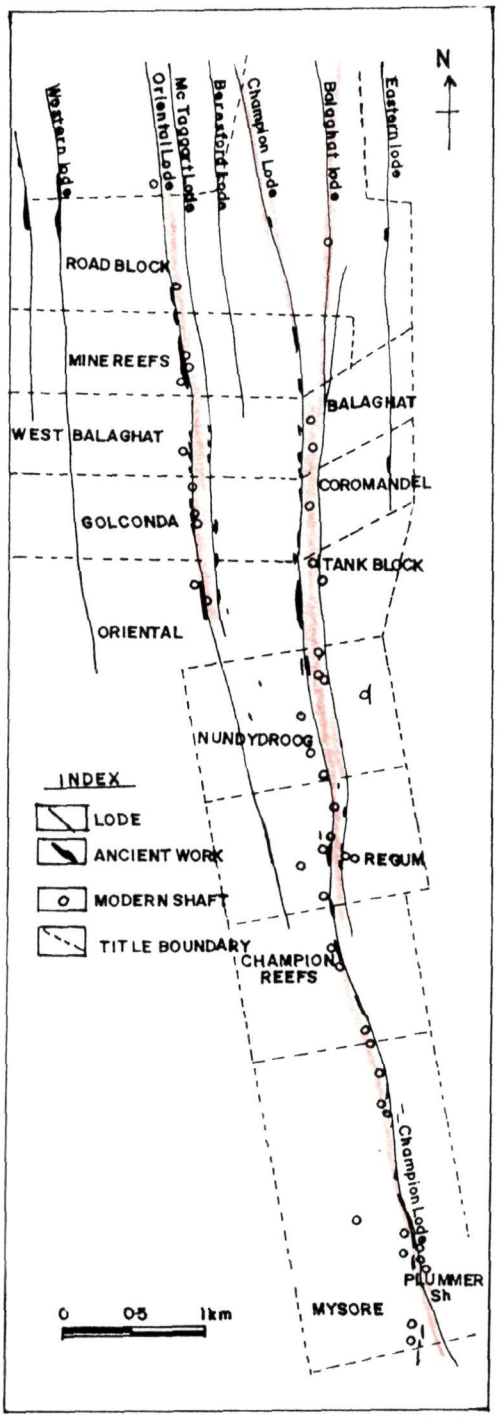
At present there are two major gold producing mines in the country. Kolar Gold mines, where modern mining started in 1880 has a unique record of 115 years of continuous gold production (highest gold production was in 1905 with a recorded 19,187.17 kg. of metal). Owing to many problems of deep mining, the production has dropped down at present substantially. Nevertheless, it has the distinction of the first metalliferous modern mine and has set standards for opening other mines in terms of mining techniques.

The other one is the Hutti Gold mine in Raichur district, which is now the highest producer of gold in the country. Ramgiri mines of Andhra Pradesh is contributing in a small way. The combined production of all these mines is not exceeding 2 tons annually. (South Africa alone produces more than 600 tonnes of gold annually).

Geological set up :

Kolar Gold field lies in the middle part of the Kolar Schist belt and is 100 km. by road from Bangalore. The Madras-Bangalore section of the southern railway passes through Kolar Gold Field via Bangarpet.

Kolar greenstone belt on the southern part of the Karnataka Craton encompasses an area of 300 sq.km. extending in north-south direction for about 80 km with width varying from 3 to 6 km. The main auriferous lodes are located within the fissile amphibolite. Though there are more than 100 lodes, only about 26 lodes have proved to be of economic importance. Each lode has varied extension and width and invariably all the lodes have been tried by the ancients. Of all the lodes, the Champion lode system and its branches are of real economic importance. Champion lode has been observed to be discontinuous fissure filled quartz which peters out both along strike and dip. (Fig. 3.2.1)



ANCIENT MINNING AT LODE OUTCROPS
KOLAR GOLD FIELD c.1890
Based on B.G.M.L plan.
(After LYNN WILLIES 1992)

Fig 3·2·2·1

3.2.1.1. Ore genesis

The genetic aspects of Kolar gold lodes have been dealt in detail by various workers. The auriferous lodes of Kolar are considered as hypothermal, epigenetic type (Narayanaswamy *et al*, 1960, Nautiyal, 1966) the mineralising solutions emnating from the differentiating acid phases of magmatism surrounding the greenstone belt. Ananth Iyer et al.(1970, 1976) have linked metamorphic secretion process for gold lodes towards the waning stages of Dharwar orogeny. The sulphur rich gold quartz veins are believed to have been formed under low sulphur, Co_2 and continuing pressures under amphibolite facies condition. The importance of mangnesian basaltic lava largely derived from the mantle for major gold deposits of the world has been emphasized by Viljoen (1984). High magnesian basalt have been described from Kolar gold field (Ananth Iyer and Vasudev, 1979, Rajamani, 1985). The isotope composition of lead in the galena in Oriental lode, is comparable to mantle source lead (Safonov *et al*, 1984). The most productive mineralisation post dated the major folding and metamorphic episodes and was formed in shear belts by upward influx of hydrothermal fluids (Mukherjee and Natarajan, 1985).

3.2.2 Gold mining activity in Kolar Gold Field

Ancient workings of Kolar Gold Field have served as guide for modern mining. On the Champion lode, the old workings follow one another in close succession for nearly 8 km. In the early part of the present century, the old workings were encountered at a depth of upto 300 ft. (Smeeth and Sampath Iyengar, 1916). The Champion reef section yielded 4 oz gold per tonne at 300 feet depth in Taylor's shaft, sunk on an ancient working (Hatch, 1901). Not only in the main Kolar Gold Field, even the southern and northern extensions of Kolar schist belt have innumerable gold workings. The ancients have not only tried the auriferous quartz lodes but have not missed the mineralised banded iron formation. (Fig.3.2.2.1)

The earliest historical record shows that in 1802, Lt. John Warren of H.M. 33rd Regiment of Foote, while engaged in a survey of eastern Mysore heard rumours of a gold discovery in Oorgaum and collected a small quantity of gold after panning the old workings and subsequently carried out detailed work by following Palar and Pennar river alluvium. He started his work from Errakonda on the southern part and his main aim was to demarcate the boundary between erstwhile Mysore and Madras states. It was for the first time ancient workings were brought to light which now form part of the auriferous belt of the Kolar Gold Field. His work has been recorded in the annual Asiatic Register of 1804 under the title "Observation on the golden ore found in the eastern province of Mysore in the year 1802". He has described in great detail the Oorgaum mines which were operated on a small scale by local villagers. His account includes the method of winning gold by locals using quick silver. For a long time there appears to be no progress in the search for yellow metal in this part.

The establishment of a cantonment in Bangalore after the fall of Tippu Sultan in the Fourth Mysore War, the introduction of a system of subsidiary alliance by the Marquess of Wellesley and the salubrious climate of the Karnataka plateau provided a powerful incentive for the British soldier expatriate to settle down in India. One of the easiest way to keep busy during retirement was to become a planter or seeker after gold. The plateau around Ootacamund was an obvious choice because one could become a planter as well as a fortune seeker in gold. When the "Wynad Boom" to strike, it rich, in the Ootacamund area proved a failure, the attention was turned to Kolar Gold Fields, famous from the ancient times for its gold mines, and made more famous by Tippu who hailed from this district and was actively engaged in gold mining. The main deficiency was the labour which was found in the neighbouring district of North Arcot.

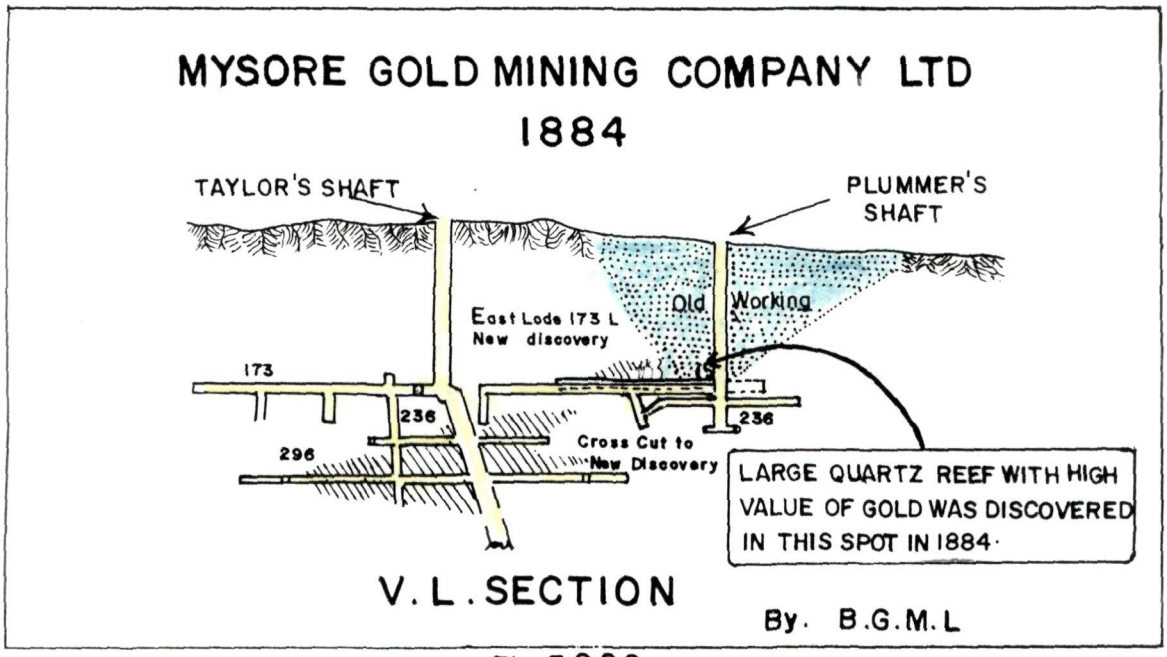

MYSORE GOLD MINING COMPANY LTD
1884
TAYLOR'S SHAFT
PLUMMER'S SHAFT
East Lode 173 L
New discovery
Old Working
173
236
296
Cross Cut to New Discovery
236
LARGE QUARTZ REEF WITH HIGH VALUE OF GOLD WAS DISCOVERED IN THIS SPOT IN 1884.
V. L. SECTION
By. B.G.M.L

Fig 3.2.2.2

It was in 1880 that a syndicate of Bangalore military residents obtained a concession and commenced to work at Oorgaum. They soon abandoned the operations and the real pioneer of the existing mines is undoubtedly M.F.Lavelle, an old Irish soldier who commenced prospecting the ancient workings at Kolar in the year 1871. Surprisingly, Lt. Lavelle asked concession for prospecting coal! Two years after, he obtained from the Mysore Government a concession for 20 years over a large tract of country round a scene of his operations. In 1876, Lt. Lavelle handed over his rights to Beresford and others who later formed a small syndicate, the Kolar Concessionaries which after various vicissitudes was transferred to a syndicate that obtained Messrs John Taylor and Sons as Managers in the year 1880. In the initial stages, prospecting of the ancient workings by the various companies which were floated did not yield encouraging results but in the year 1884, Captain Plummer of Mysore Gold Mining Company while concentrating his operations in a shaft of 55m deep near the extensive old workings at Marikuppam, was driving on a direction opposite to that favoured by most of his predecessors, soon came on the reef but amongst ancient workings. Fortunately some pillars of quartz worth 120 gms/t. had been left in the old stopes. An effort made to bottom the old workings thus paved the way for the discovery of the famous Kolar Gold Mines (Fig.3.2.2.2). The discovery was a shot in the arm for the other companies which floated fresh capital. By the turn of the century, many companies were formed for prospecting the Kolar schist belt. The big five companies which eventually lasted and started their operations by making huge profits were (1) The Mysore Gold Mining Co., (2) The Champion Reef Gold Mining Co., (3) The Oorgaum Gold Mining Co., (4) The Nundydroog Gold Mining Co., and (5) The Balaghat Gold Mining Co.

GEOLOGICAL MAP OF HUTTI-MASKI SCHIST BELT. KARNATAKA

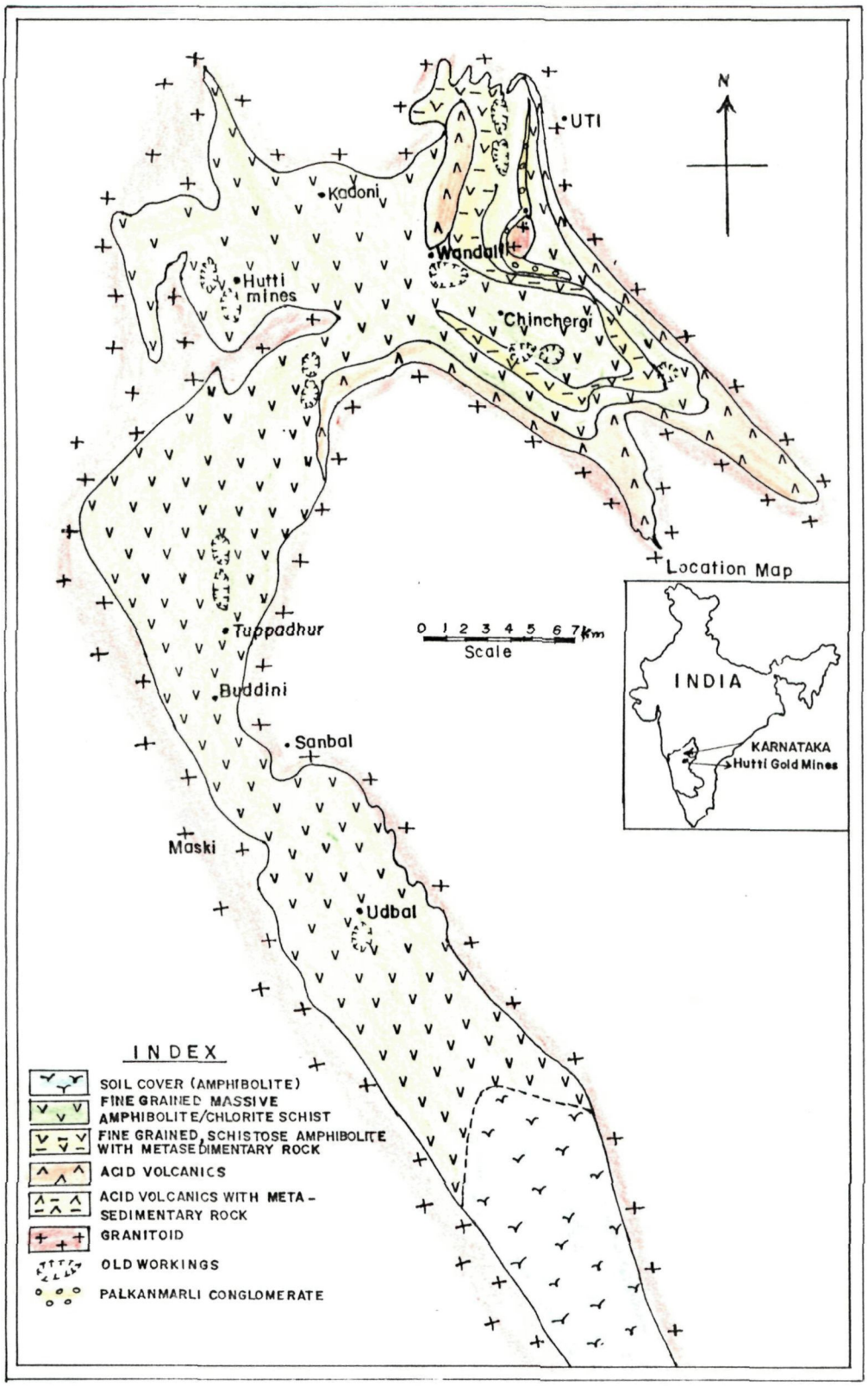


Fig - 3·2·3

Gold mining activity in the rest of India, though on a small scale and under primitive conditions, was continued by local people in the south as well as central and north eastern India. The Kolar Gold Mines too would have suffered the same fate as those small scale operations but for a major turning point in its economic history. In the year 1902, hydroelectric power from Sivasamudram was made available by one of the first long distance power transmission lines in the world to the gold mines. With cheap and abundant power that was not available for another half a century even in the other mining regions of Mysore State, not to speak of other gold bearing areas in the rest of India, Kolar Gold Mine was able to maintain uninterrupted progress while gold mining activity in the other parts could not go beyond primitive dimensions and finally came to a grinding halt. (B.G.M.L. Report, 1979)

3.2.3 Hutti gold field

Hutti gold field is located in Raichur district and takes its name from the village Hutti (Lat. 16°12'N-Long.76°43'E) of Lingasgur taluk. It is about 480 km north of Bangalore and 80 km. west of Raichur. Hutti is almost in the midway between western and eastern ghats.

It was formerly under Hyderabad state. Hutti and Kolar Gold Fields received attentions of the prospectors almost simultaneously, in the later part of the 19th century. It is the magnitude of ancient workings for gold that attracted the prospectors during Nizam's rule in Hyderabad.

The Hutti-Maski greenstone belt covers an area of 750 sq.km. and is made up of heterogeneous assemblages of volcano sedimentary rocks. Metabasalt predominates over acid suite and metasedimentary rocks are exposed on the eastern part. Granitoids surrounding the schist belt maintain intrusive relationship. (Fig.3.2.3)

Gold mineralisation is confined mainly to massive amphibolite conforming to the regional tectonic trend of the schist belt.

Before modern gold mining started in Hutti-Maski schist belt, systematic surveys carried out by Bruce Foote, Maclaren and Leonard Munn, in the later part of 19th century and the early part of present century brought to light a galaxy of old workings scattered over this auriferous belt. (**Plate 13A**)

3.2.4 Magnitude of ancient workings in Hutti gold field

Hutti Gold Field is practically dotted with chains of old workings. The important workings are Wandalli, Kadoni, Budini and Maski. The former Hyderabad (Deccan) Co., opened a new era of rediscovery of ancient mines. Till 1800, no organised mining seems to have carried out in Hutti area. In fact, the main Hutti mine is located on one of the ancient workings discovered by prospectors of Hyderabad(Deccan) Co. Half a kilometer west of the village, float quartz carrying gold was discovered which the prospectors of the company discovered as the spot of ancient workings.

In 1887, Mr. T.W. Hughes of the Geological Survey of india, basing his prospecting on Bruce Foote's geological work discovered gold bearing reefs and ancient workings for gold in the Maski Schist band of the old Hyderabad State, and within the same year the mineral rights within Hyderabad State were bought by the Hyderabad(Deccan) Company.

This company entered upon an intensive programme of prospecting and mine development and between 1887 and 1899 discovered and examined at least three hundred different gold occurrences in the Raichur Doab and the Surapur taluk. Only a few of the ancient workings discovered were ever unbottommed and little more is known now about many of them than before they were discovered and the Hyderabad (Deccan) Company seems to have

spent a great deal of money with no return. Together with its subsidiary company the Wandalli (Deccan) Gold Mining Company Ltd., the company spent over £400,000 in prospecting and mine development in the Hutti area.

The Hutti (Nizam's) Gold Mines Co., was formed in 1901 specifically for the exploration of the Hutti deposit(Main Reef). A separate company had been formed in 1895 to work the Wandalli lodes and the Topuldoddi(Deccan)Gold Mines was formed in 1905 to work the deposits there. All the three companies were offshoots of the Hyderabad(Deccan) Company. The two latter companies failed, for a variety of reasons, but the Hutti company had a profitable career and continued to work until 1920.

Nature of old workings and their extent is described in great detail by Macleran (1906).

WANDALLI : Wandalli ancient workings are located about 12 km. to the east of Hutti mines. Macleran writes that attention was early attracted to this place by the great number of old workings in the vicinity. Some of these were 100 to 150 yards long, 20 feet wide and as much as 15 feet deep. Exploration was commenced in 1888 and continued for seven years by spending £20,000 and sinking five shafts. Only one of which was well below the old workings. In the west shafts 238 feet deep, the old workings had not been bottomed. In No.3 shaft, 2000 feet east of west shaft, the old workings were reached at 380 feet. Between 1896 and 1901, the mine produced 465 kg. of gold and inspired the company to proceed further to form subsidiary companies to work the prospect.

KADONI : Kadoni mines are located about 6.5 km. to the northeast of Hutti mines. Here also the old working occur as clusters running N.W.-S.E.

F.M.Grey in his report of March, 1898 (Report on the Gold properties of Hyderabad (Deccan) Co., page 11) records :

> The ancients have taken away practically everything down to about 140 feet, there does not appear to be any old working to the north, but there is so much cotton soil and cultivation here that an old working might easily be covered up or so filled in as to be scarcely distinguishable from the surrounding country.

BUDINI : Budini workings are located 25 km south of Hutti mines. Ancient workings are distributed over a strike length of 1100 m. The Budini mines were opened in 1888 to explore the reef below the ancient workings. The shafts were sunk through the large ancient working.

At Budini and Wandalli, many of the ancient stopes were completely cleared out by the old companies and there can probably still be seen standing open to a considerable depth. Some are partially filled with rubbles and others are flooded. The ends of ground are generally narrower than the working itself with only a narrow quartz vein and stringer to be seen and the excavations are mostly in delapidate and dangerous condition.

HUTTI MINE : The Hutti (Nizam's) Gold Mines Company Ltd., was formed in 1901 to develop ancient workings discovered near Hutti village which is located about 80 km. due west of Raichur. The Mine was skillfully operated and during the period 1902-1919 paid substantial dividends on the paid up capital. The Main Mine reached a depth of 3500 feet and 417,000 tonnes of ore was treated for a yield of 237,000 oz of gold. The grade of ore milled was over 11 dwt. per ton and the mine worked until 1920 when high working costs and the exhaustion of payable reserves brought about its closure. It is of interest to note that the ancient workings in this mine were found to extend to a depth of over 640 feet on the reef and are the deepest known of their kind in the world.

TOPALDODDI MINE: In the early days of prospecting, numerous ancient workings were discovered near Topaldoddi and Chinchergi villages about 4.8 km to the south east of Wandalli, but it was not until 1905 that the Topaldoddi Gold Mines Ltd., was formed with an authorised capital of £ 90,000 to explore them. Several pits and shafts were sunk and buildings and machinery were erected but no original records now remain of the working of the mine. 2,132 oz of gold was produced but the grade was too low for profitable operation and the exhaustion of funds brought about the closure of the mine in 1908. The lease was transferred to the Hutti mine but no further work was done. **(Plate 13B)**

MASKI : Many ancient workings were discovered by the prospectors of the Hyderabad (Deccan) Company but no record of any underground exploration was traced. Work was taken up in 1905 or 1906 by the Deccan Gold Fields Company Limited and a number of ancient workings in the Maski area were investigated. It appears that in every case with the exception of the Maski NO.7 old working sinking through the old workings was frustrated by flows of water and work was suspended before any real information of value was obtained, though in some cases encouraging assays were obtained from pillars of quartz and remnants left by the ancient miners.

In 1938, the Maski area was partly re-examined by the Hyderabad Gold Development Organisation and intensive surface prospecting was undertaken by Mr. F.N.Chelmeley and other members of Messrs. John Taylor & Son's staff. A geophysical party was in the field and systematic soil pannings were also carried out over a large area. Favourable indications were trenched and a number of ancient workings were discovered below the heavy mantle of cotton soil that covers the area.

Secondary deposits constitute another source for economic consideration. Primarily guided by weathering of parent rocks, gold particles released are transported and concentrated. The density of gold (19.3) coupled with chemical inertness are the added advantages for concentration of gold in favourable places, particularly in association with alluvium, sands, gravel and conglomerate. Such deposits have been worked for centuries, where gold has been recovered as nuggets and smaller particles. According to one estimation nearly 20% of the present world gold production comes from the secondary sources.

The formation of placer gold deposits and the geological condition favourable for gold concentration by secondary process has been described by Ziauddin and Narayanaswamy (1974, pp.31-33):

> Placer deposits have always attracted the attention of man and have contributed in a larger measure to the gold production of the world in the early history of gold mining. Considerable quantities of gold are reported to have been won from placers in California, Klondike, Victoria and New Zealand.
>
> Placer deposits are formed mostly by the action of water whereas only a few are formed by the action of wind and glaciers. It is the former class which has yielded the richest gold placers of the world. Deposits of placer gold are found both in the present day river courses as well as in buried valleys and sedimentary basins of earlier geological times. Majority of the placers are, however, confined to the Tertiary and Recent age whereas only a few belong to other periods.
>
> In the process of formation of the auriferous placers, the gold bearing rocks or auriferous vein material are first disintegrated mechanically and chemically by the agents of weathering and denudation, and gold, both in the free state or in combination with other elements, is set free. It is subsequently transported and concentrated at different places of the drainage system. While most detrital gold enters the water-course, a portion is accumulated on the hill slope to form eluvial or residual deposits. Deposits of this kind have originated as a result of weathering of hundreds of feet of auriferous material for a considerable period of time....
>
> Gold is concentrated in the bottom of the stream bed above the bed rock and below the gravel, as it is five to six times heavier than the ordinary rock. In some cases, however, it is arrested on the top of the clay layers within the gravel while in others it is deposited in the joints and crevasses of bed rock itself. Some of the favourable places for gold deposition are those where the bottom of the stream valleys

are rugged thereby facilitating impounding of the gold particles and preventing their escape. Gold which is deposited in places close to the source of parent material if often coarse but as it travels down with the gravel, it is comminuted and carried in a fine state in suspension. The concave side of the stream beds and the downstream sides of the rocky bars are also ideal sites for gold deposition. When gold is distributed widely scattered in places, the entire material is treated on a large scale by dredging. However, when it is concentrated it forms what is called "pay streak" or "run of gold." The pay streak generally has a sinuous course or irregular in outline, narrow and rich....

Auriferous placers are rarely met with in big rivers as no gravel is allowed to be deposited owing to the large volume of water which flows into them. However, gold may be deposited in sand bars in a fine state but these deposits are not of much commercial value. Similarly, deep gorges with polished bottoms are not favourable places for deposition of gold.

The importance of alluvial or placer gold exploration is emphasised by Boyle (1985,p.2) in the following sentences :

Auriferous placers provided early man with the first sample of gold, and since that time have accounted for a large production of the metal. If we include the Wittwatersrand and other quartz pebble conglomerates has fossil placers or modified fossil placers then the placer type of deposits has provided more than two-third of man's store of gold.

It is interesting to note that gold rush in California between 1848 and 1856 added 752,400 kg. gold to the world resource and the chief source was placer gold.

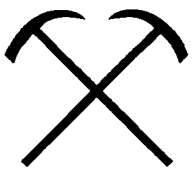
In India too, it was Wynad gold field which hosted gold boom of 1880 to 1900 and its discovery is attributed to its ancient gold washing industry near Nilambur, Kerala as early as 1793. It is reported that nearly 500 to 600 persons were engaged in panning the gold when European prospectors visited this area in 1874. Ultimately 33 companies with an aggregate capital of £ 4,050,000 were floated in London and between 1880 and 1883, a total of 14.9 kg of gold was recovered (Ziauddin and Narayanaswamy, 1974). In fact, it was Wynad gold boom which attracted the European prospectors to intensify their search for yellow metal which ultimately lead to the development of Kolar gold Mining industry.

Chapter 4

PLACER GOLD

Nobody could ever have conceived of a more absurd waste of human resources than to dig gold in distant corners of the earth for the sole purpose of transporting its and reburying it immediately afterwords in other deep holes, especially excavated to receive it and heavely gaurded to protect it

- Prof. Robert Triffin (1961)

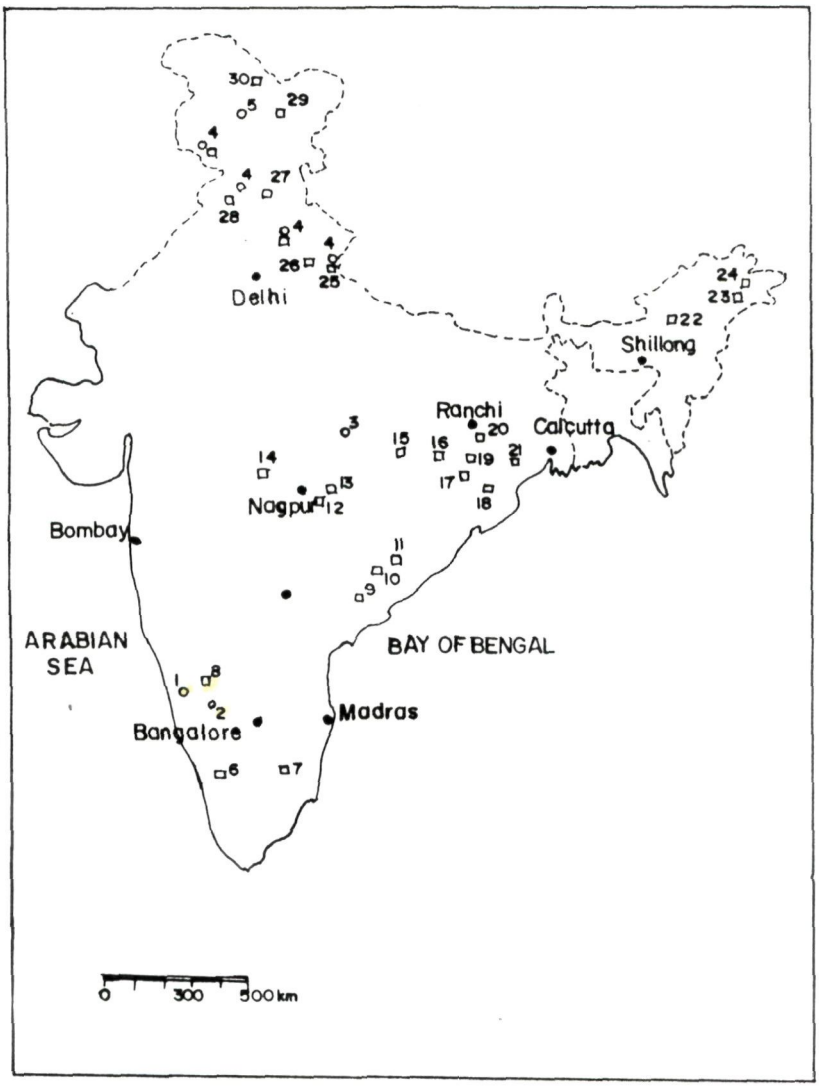


PALAO- PLACERS

1. Western ghat belt
2 Bababudan belt
3 Bijawar group
4 Siwalik group
5 Aurel-Sherali thang

PLACERS

6 Nilambur
7 I.M. Palyam
8 Kuderakonda
9 Bhadrachallam
10 Supna ghat
11 Govidapalli- Kollaru
12 Pular
13 Kokha
14 Pachdhar
15 Sonakhan
16 Kochuakani- Bangaon
17 Kullhari group
18 Sonapenth- Biminipal
19 Ankua
20 Sonapet
21 Kamorara-Subernarekha
22 Barapani- Buragaon
23 Moko- Gurimara
24 Nijamghat- Parghat
25 Debi- Dhura
26 Sonawadi-Lakshman jhola
27 Samsi
28 Rai
29 Skio
30 Kapalu



SECONDARY GOLD DEPOSISTS OF KARNATAKA AND OTHER PARTS OF INDIA

(Geological society of India 1991)

Fig 4 ·1

4.1 PLACER GOLD OCCURRENCES IN KARNATAKA

Compared to the magnitude of exploration of lode deposits, placer gold mining seems to have received lesser attention in Karnataka. Nevertheless, it was the placer gold washing which opened new avenues for modern gold mining. From the records by European prospectors it is understood that the placer gold mining was at its peak in the 18th and 19th century in many parts of Karnataka. Though, not of economic significance, placer gold mining was practiced on small scale by a community of a people called *jalagars*, who were earning their daily bread by practicing this profession. Notably, the auriferous tracts of Tungabhadra river in Shimoga belt, stream flowing through the northeastern part of Harapanahalli in Bellary district and the streams flowing through Doni, Sortur, Harti, Jelligeri in Gadag part are known for the placer gold washing. (Fig.4.1)

4.1.1 Gold panning in Gadag area

Gadag gold field covers an area of roughly 128 sq.km. located in Gadag and Shirahatti taluks of Dharwar district. It forms part of the well known Gadag-Chitradurga schist belt extending over a total distance of 430 km. from near Gadag in the north to Srirangapatna in the south.

The gold field extends from about 10 km. south of Gadag(Lat.15°25'N - Long 75°38' E) in the north to Jelligeri about 14km. further south with a maximum width of about 8 km at the center.

Geologically, it represents the remnant of Archaean metavolcanic and metasedimentary rocks.

In Gadag gold field, gold in localised in phyllites near the contact of green stone, and in sheared and schistose amphibolites along the contacts of quartz porphyries. In common with the other gold deposits, gold is intimately associated with intrusive quartz vein and is predominantly a free gold. Only a small proportion of the gold is associated with the sulphide minerals.

Gadag gold field has a long history of gold panning. Panning for gold in the streams between Doni and Sortur has been recorded by Captain Newbold as early as 1842.He mentions that about a kilogram of a gold was recovered by panning in the streams. Further he records that banks of gold yielding streams were crowded with *jalagars*.

A detailed account of auriferous quartz reef from Attikatti area about 13 km. due west of Dambal is given by Foote(1874). He has recorded a number of ancient workings from this part of Gadag gold field.

Alluvial gold washing in this part has been elaborately described by Foote in his paper "The auriferous rocks of Dambal hills, Dharwar District"(p.137-138). Some salient observations on the method of gold washing as practiced during those years is briefed below:

> The washing for gold in the sands borne by the various streams flowing through the auriferous tract is carried out by a class of men called *jalagars*, and they are now very few in number compared to what is reported about them in former years. I could only hear of three, two of whom were at Soortoor, and the third lived at Seerhuttee, in the Sangli Jaghir. I obtained the services of the two former, and made them wash for me in the Dhoni, Soortoor, Jilgerree, and other nullahs on the west flank of the Kappatgode. Of these nullahs, the Soortoor nullah was by them stated to be the richest, and this statement was fully borne out by the results obtained when washing there in my presence. Next in productiveness came the Dhoni stream, but the yield was greatly smaller, and hardly enough to remunerate them for their labour. In the Jilgerree nullah they got a yet smaller return; and in the other nullahs, including that at foot of the Kapat Iswara ravine, only a very few exceedingly minute spangles were obtained, just sufficient to show that gold was not entirely absent from the detrital matter...
>
> The method of washing adopted is simple, but might be made more effective

at very little expense. The wash-dirt is scooped up with a small stout, broad hoe with a short handle, and carried in a basket or large wooden tray to the washing box, which has been fixed at the water's edge and propped up with stones to the required slope. The washer sits on a large stone in the water close to the side of the box, which is an oblong construction, made of light planks and open at one end. It is about 3 to 3.5feet long, 20 inches wide, and 9 inches deep, and strengthened with clamps. A stick of some elastic kind of wood is jammed against the sides and bottom at the lower and open end to form a catch. This done, the washer begins to ladle water on the wash-dirt, kneading it the meanwhile with the left hand and throwing out all the large pebbles. The ladle or rather scoop used by the *jalagars* was made of a long calabash, with one end cut off. It was held by the middle , an oblong hole having been cut into the incurved side, and a couple of small sticks tied across diagonally to the corners and fixed with strings passed through small holes. The elder man of the two, however, preferred to use a tin pot with cross handle, which had been given him by a former Collector of Dharwar. This goes on till a layer of sand has been formed in the box, so thick that the stick at the lower end is no longer a sufficient catch, and second stick is jammed in and the washing process re-commences till the sand layer has raised almost level with the second stick; both stick are then removed, the washer stirs up the layer of sand with a short, stout piece of wood and then sweeps everything into the large wooden tray held below the open end by the assistant. The washer then takes the tray, places it in the water, and performs the needful shaking and washing, technically called "panning off", till nothing remains at the bottom but fine sand, generally of black color. He then tilts the tray a little, and by judiciously dropping water out of his hand on the small layer of sand drives all the lighter particles forward and leaves the spangles of gold exposed. This small residue is then collected carefully by washing down into a half coconut shell, and taken home to be treated with mercury.

Subsequently, Malcom Maclaren, a mining specialist from Geological Survey of India, visited the Gadag gold field and has recorded decline in panning activity in this part due to liberalised policies of land revenue which ultimately prompted the locals to take up agriculture on a larger scale. However, *jalagars* were actively engaged in washing gold from Sortur, Doni and Jelligeri streams, even in the first decade of 1900.

It is interesting to note that two hills in the central range of Kappatgudda bear the name of gold as mentioned by Lt. Aytoun(1852). He undertook the survey of mineral resources of Bombay-Karnataka and subsequently recorded his findings in trans. Bomb.Geol. Soc. vol.XII.

Maclaren further records levying tax on the gold washers. He may be quoted here(p.116):

> The Desais are chief of Dumbal formerly levied a tax on the gold washers , but these appears to have pursued their calling free of taxation after the death in 1800 of the last Desai who was hanged, apparently as the result of misapprehension over the gate of his own fort by the duke of Welington.

4.1.2 Gold Panning in Shimoga area

Panning for gold in the alluvial soils of river or streams that drained the auriferous tracts, particularly in parts of Shimoga and Chikmagalur districts drained by Tunga and Bhadra rivers and their main tributary streams is quite an old practice since generations. The washing of alluvial gold at several places by *jalagars* was in practice as late as 1960 particularly Kudrekonda and Pallavanahalli regions of Honnali taluk Shimoga districts are known for gold panning (Rama Rao 1962).

Extensive washing operations were conducted by the erstwhile Mysore Geological department in the beds of the Tungabhadra river between the villages Holalur and Govinkere in the Honnali and Shimoga taluks in 1936. Similarly, panning of the secondary gold in the vicinity of Kudrekonda and Pallavanahalli was taken up by the department between 1940-41.

Kudrekonda workings are located 15 km. south west of Honnali, Pallavanahalli is located 18 km. S.S.W. of Honnali separated by a distance of 10km. gold mineralisation here is reported from the quartz vein.

Gold occurrence in Kudrekonda area was discovered from the surface showings of gold in the residual soils and float quartz presumably derived from the nearby underlying quartz veins. The largest nugget recovered in 1907 weighed 139.9 grams. and the largest and richest lump of float quartz weighed 6.7 kg containing of about 1.39 kg. of gold. Honnali gold mining company between 1880-85 mined this area by sinking a shaft and recovered

16.4 kg. of gold by crushing 2353 tons of quartz (Ziauddin and Narayanaswamy, 1974). Panning at Pallavanahalli on a small scale by the state department yielded 20 *tolas* or 8 oz. of fine gold (Rama Rao, 1948).

4.1.3 Gold panning in Bellary area

The earliest report of gold washing in Bellary district is from Dr. Balfour who recalled a vague report about the gold occurrence in streams draining Kanavihalli and Jaikalgudda (Cyclopaedia, 3rd Ed. Art. Gold. page 1222).

Subsequently, Foote visited this area in 1895 and witnessed the gold washing by *jalagar* in several small streams flowing from Jaikal gudda, 10 km. E.N.E. of Harapanahalli. Foote attributed the source for gold to the bluish quartz. He considered it as the best yield from Konganhosur stream which flows from northeastern flank of Jaikalgudda and the second best yield was from a small stream north of Chigateri and Konganahosur. The gold reported by him was of the size of 'pepitats'(Cucumber or Melon seeds) with a good colour.

When Maclaren visited these areas in 1905, *jalagars* from Hampi were engaged in panning after the conclusion of the rains (Rec. Geol. Sur. Ind. Vol.XXIV, p.120).

4.2 INSCRIPTION AND LITERARY REFERENCES FOR GOLD PANNING IN KARNATAKA

That, alluvial gold washing was well practiced in the 12th Century A.D. in Gadag part is evident from one inscription of 1126 A.D. This inscription is on a pillar in the temple of Virupaksha, in Kurthakoti, Gadag taluk, Dharwar district. It is reproduced below:

No.20

B.K.No.123 of 1926-27

This inscription refers to the *Chalukya-Vikrama kala* and is dated *saka 1048, parabhava, Jyestha, amavasye, Monday, Solar eclipse corresponding to A.D. 1126 June 22, Tuesday 44* the date of the record falls in the *Chalukya Vikrama year 51* the amavasye commenced at .47 on Monday. The saka year cited was current and the month was nija Jyestha. It registers a gift of certain taxes by *Kesaraja, the Sandhi vigrahin* of the Dandanayaka Sellappayya for the worship of God Daseshwara of Kurthakunte. The Doni 1000(guild) received the gift which was to be protected by them and the 200 mahajanas headed by *Urodeya Swamikumara Bhattopadhyaya.*

The tax referred to in the inscription is *jaragina tere* which was levied on gold washing during those days. The officer in charge of collection of such tax was called *jaraginadhikari.*

This inscription throws light on gold washing which might have been quite a good source of revenue in the 12th century A.D.

In his work *Dharmamrutha*, Nayasena, a jain poet of 1112 A.D. from Mulugund, Dharwar district, also refers to the process of collecting gold particles by washing the sand along the beds of the banks of the river.

Similarly, Chalukya Someshwara III of 1126 A.D. in his compendium *Abhilashitartha Cintamani* or *Manasollasa* has made an interesting reference to gold and precious stone. He advised the king to protect such places where gold (*suvarna*) silver(*rajata*) and precious stones are found. This has been interpreted by J.D.B. Gribble as the gold mines, the existence of which was kept under profound secret (Gururajachar, 1974).

The *vachanakaras* of 12th century A.D., notably Allama throws light on the gold washing by giving analogy and simili (Basavaraju, 1960, p.25)

Meru parvathadoliddu jaraga toleva chinthe eke? (Why bother about gold washing when you are right on the mountain of gold - Meru?).

Meru is supposed to be the mountain of gold. It has been now identified with the Altai mountain in central Asia. Altai mountain is altain-ula in Mangolian which means mountain of gold (Paramananda Gupta, 1973).

The word *jaragu* appears in many kannada texts of 12th and 10th century A.D. Notably among these are *Basavannana Vachanagalu* of 1160 A.D. (Ed. by Halkatti, p.31), *pampa ramayanavemba ramachandra charita purana* of Nahgachandra who lived in 1100 A.D.(Ed. by Rice, 1862, 5.20),*Chandraprabha purana* of Aggala who lived in 1189 A.D. (Ed. S.G. Narasimhachar and M.A. Rama Iyengar, 1901, p.9.70), *Vageeshwara Deva Ragale* of Harihara who lived in 1200 A.D. (Oriental Research Institute: Manuscript K.348, 265.05), *Nemichandra purana* of Nemichandra who lived in 1120 A.D (Ed. B.Sannayya, 1961, p.2-4), *Sukti Sudhakara* of Mallikarjuna who lived in 1245 A.D (Ed. A.S. Anantha Rangachar, 1947, p.4-7).

Among the 16th century texts, 2 important works in which the word *jaragu* is mentioned are *chandraprabha Sangatya* of Doddaiah, who lived in 1510 A.D. (Oriental Research Institute, Manuscript No.K.69, 23.7) and *Cherama kavyam* of Cheramanka, who lived in 1526 A.D. (Ed N. Basavaradhya, 1956, 6.49).

Though, no geographical identity can be attached, one inscription (SII IX i-249) makes a reference to gold mine under the name *Pongani*. This inscription is found on a stone lying in the Suryanarayana temple at Kolur, Bellary taluk and corresponds to 1147 A.D.

There is little doubt about the large scale washing for gold which was practiced in Karnataka since generations. This is borne out by the fact that about 20 km west of Tarikere and 3 km to the south west of Lakkavalli, there are numerous pits and old prospects which are now mostly submerged after

the construction of Bhadra Reservoir near Lakkavalli. These pits have been named as *jalagaragundi* mines (Ziauddin and Narayanaswamy, 1974).

4.2.1 Place names connected with gold occurrences in Karnataka

Philology, even in the hands of the expert, sometimes leads to very erroneous conclusions, but undoubtedly the ancient Kannada words *Honnu* and *Chinna* meant gold. It is curious to note that villages with these affixes are not found far off the belt of gold bearing rocks. This interesting observation was made by Capt. Leonard Munn in 1934. Similar observations were made by archaeologists and geologists who are quite familiar with the vernacular of this state. Panchamukhi observes (1941,p.82) :

> Further, in Hungund, Honnavar, Honnali, Pongame etc. the very names would indicate that gold was associated with them - traces of ancient gold works have been found.

The alluvium of most of the rivers draining the auriferous tracts of India contain disseminated gold. Names like *Suvarnavathi*, *Suvarnarekha*, *Honnuhole*, *Ponnu puzha*(Golden stream) points out that these rivers were known for their concentration of alluvial gold (Radhakrishna and Curtis, 1994).

Following are some of the names of the places connected with gold occurrences in Karnataka.

Bangarpet	*Kolar Dist.*
Chikhonnkuni	*Raichur Dist.*
Chinmulugund	*Dharwar Dist.*
Honnabetta	*Mandya Dist.*
Honnali	*North Kanara*
Honnehatti	*Shimoga Dist.*
Jalagaragundi	*Chikmagalur Dist.*
Jalagaranahalli	*Chikmagalur Dist.*
Suvarnamukhi	*Chitradurga Dist.*

The details of gold occurrences connected with these places is discussed in Chapter 3.2 under the heading "Distribution and status of ancient workings for gold in Karnataka".

4.2.2 Some place names and gold occurrences outside Karnataka

The place names connected with gold is valid not only in Karnataka, but outside the state also. *Sonapet* (gold town) in Chota Nagpur plateau, Bihar was an early active centre for gold panning. In 1889, a big nugget of gold weighing 28.6 g. was recovered during panning. According to the estimate made (Neotling 1890) the potentiality of this area was 77.7 kg. of gold production annually which in 1890 led to the floating of 32 gold companies. Among many rivers, where active panning was going on in Bihar were *Sona* (gold) *Subarnarekha* (goldline) in North Bihar.

Assam is known for production of placer gold since a long time. Among many rivers draining into Brahmaputra, *Subarnasiri*(gold treasure) happens to be a very important one. From the records of Jean Baptiste Travernier, it is understood that 12,000 to 20,000 people were engaged in gold washing in Assam and between 1751 and 1768 A.D. about 50 kg. of gold was paid annually as revenue to Rajarajeshwar Singh (Ball, 1881).

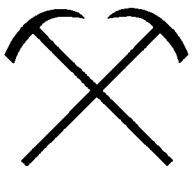
In Banswara district of Rajasthan in the vicinity of Bhukia village near Ghatol, a cluster of ancient workings for gold (About 50) spread over 6 sq.km. area has recently been located by Geological Survey of India. These workings are in marble and quartzite, extending upto 300 m. in length 10 to 30 m. in width and upto 20 m. in depth. Gold has been recovered from the dumps which carries upto 9.0 g/t. The presence of ancient tribal temple *Hiranyabeejawa Maa* (Goddess of the land of gold) situated on the bank of Shakliya river near Haro dam, Ghatol gave impetus for re-examination of the area more closely. (Grover and Verma, 1993).

Chapter 5

ANCIENT MINING TECHNIQUES AND METALLURGY OF GOLD

Get gold, humanely if you can, but at all hazards get gold

- King Ferdinand of Spain (1511 A.D.



Metalliferous mining, irrespective of the geological formation, demands underground excavation. In the absence of explosives as is used today, by modern mining, the only method known to the ancients were fire setting and quenching. Not only are there evidences for fire setting in Hutti and Kolar gold mining areas, we do have analogy from Zawar mines where zinc mining and smelting has a recorded history of more than 2000 years.

Fire setting in general was common for both gold and base metal mining. It was practiced in Khetri copper belts in Rajasthan and is described by Captain Brooke (1830, Quoted by Kerr Cross, 1950, p.7) :

> At the head (working face) of the mine, (kan), a quantity of firewood is collected, and stacked in a compact manner to the amount of 150 to 200 mounds (5 to 7 tons), which being set on fire, the miners make their escape as fast as they can, to avoid chance of their being smothered in the gallery, for some accidents are said to have happened in this manner. On the third day, the workmen descend into the mine and find that the interior of the rock has been rent and split into huge masses by the violence of the heat; and they then proceed, if the mines sufficiently cooled, to carry on the drift.

Hutti gold mines offer the best example for fire setting and the techniques employed by the ancients to reach the greatest depths, Munn records (1936, p.103-4) :

> Beyond fire-setting, followed by the quenching of the overheated rock, resulting in fracturing the gold ore, it would appear, from the very few instances of implements found, that the only other tools used by the ancients were an iron gouge and stone hammers with which they gouged out the fractured quartz. One example of an iron gouge was discovered at Hutti and, I believe, a few were found at Kolar and elsewhere. Windlasses and ropes were employed, on windlass being unearthed at Hutti, where the face of the rock was found to have been rubbed into grooves by the wear of the rope. The water was handled by chatties, a clear proof of which was the presence of about 10 feet of broken chatties found at the bottom of the old workings in Hutti mine and at similar lesser depths in other old workings that have been bottomed. The ancients seem to have thoroughly understood the practice of timbering to support their excavations, and babul (Acacia arabica) seems to have been the favourite wood employed. One piece of such timber was extracted from the old workings at Hutti, which on examination showed iron pyrites in the annular rings of the wood, bearing out the idea of extreme age. To show how much timber was

probably used, the shaft which was put down at Hutti to strike the quartz at 500 feet, instead of meeting the reef, ran into old workings and an explosion occurred, the gas undoubtedly formed from rotting timbers, an occurrence unparalleled in any other metalliferous mine...

Munn further mentions(1934,p.78-79) :

The time required to extract ore to the depth of 640 ft by this means in Hutti, must have been very great. Even allowing an enormous supply of labour, by the nature of the work, only a limited number of men could be employed in the working faces at a time owing to the extreme narrowness of the workings. And even that labour could only work sporadically as the fire-setting when in progress must have made the working faces untenable...

Many saucer -like depressions in the hard trappoid rock and large granite crushing stones *mullackers* some over a ton in weight scattered all over the Dharwar rocks, together with small pounding holes for initial crushing of the ore, give clear evidence of the metallurgical process prior to final panning. Most of the granite and dolerite mullackers have been removed to the villages where they are still in daily use; only the larger ones remain *in-situ*. A large battery of these are to be found at Wandalli.

Munn, not only has given a clear idea as to the practice of mining that was in vogue in the ancient times but also gives a clear picture of the treatment of ore after mining. In his paper on "Observations and Notes on the method of ancient gold mining in southern India, with special reference to Raichur and Shorapur districts of Hyderabad State", he records (1936, p.105) :

Once the ore was mined, the method of extraction of the gold is very clearly proved from the remains of metallurgical plants. The gold ore must first of all have been broken to the size of grain, and in places the rock is pited with small holes where this was done. It was then crushed on the hard trapped rock under boulders of granitoid gneiss and dolerite weighing from a few hundred weights upto a ton and half, which must have been rocked by hand, the larger boulders probably actuated by poles lashed to them. The best battery of crushers that has been found, lies to the north of Wandalli gold mine where about a hundred of these granitoid boulders still lie about the surface of the hard trappoid rock amidst saucer-like depressions that have resulted from the rolling action. Another set of mullackers and saucers occur on the Maski hill. Another photograph if, I think, of particular interest. It shows women employed by a contractor, who has been allowed to pick over the old Hutti dump, actually using these ancient mullackers in presumably exactly the same way as they were employed some thousands of years...

> The resulting sand was carried to the nearest water and the gold extracted by washing, probably in wooden pans, in the same way as the *jalagars* employ to-day. No dumps of sand have been found, the reason being that owing to the rarity of water on the area, the washing process was mostly done on the banks of *nalas*, where crushing plants are very frequently found".

The most important observation made by Munn is that Hutti Gold mines have the distinction of being the deepest mine in the world from the point of view of the ancient mining activity, specially by fire setting and quenching. Munn records (p.105-6) :

> First and foremost, from the extensiveness of the work done, and the slowness of the process of mining employed, it is absolutely obvious that we are dealing with a people who made no sudden invasion of the country, for the work done must have taken many hundreds of years. As a mining engineer, I am quite incapable of even suggesting an estimate of the time it would take to mine a narrow reef, by fire-setting, over a length of roughly 5,000 feet to to the depth of 640 feet. The terrible, nearly inconceivable conditions that must have existed underground makes it imperative to believe that nothing but slave labour could have been employed. No inducement of gain however high can for a moment make anybody imagine any other form of labour undertaking the work in deep mines. Even with an unlimited supply of slave labour, owing to the narrowness of the reef and the method of work, only a few slaves could have been employed in the actual working face at a time, and then owing to smoke and steam only at considerable intervals. These facts must be borne in mind when estimating the time required.

Not only in Hutti-Maski schist belt, even in Kolar Gold Fields also there are enough evidences to show that fire setting was practiced by ancients for mining activity. This is evident from the petaloid form horizontal cross section formed by fire setting in Guvalagunta mine on the southern extension of Kolar Gold Field (Lynn Willeys, 1992).

5.1 FIRE SETTING : THE OLD PRACTICE

The practice of fire setting was common not only to India but also in the European countries, the ancient mines clearly preserve evidences for this.

Craddock(1992) in his paper "A short history of fire setting " refers to many mines where fire setting was practiced. We have examples from :

1. Stone quarrying in Cumbria-Britain from 4th millennium B.C. through the early second B.C.

2. Copper mines of Ai Bunar in Bulgaria - 5th millennium B.C.

3. Tin mine of Kestel in Taurus mountain of Turkey - 3rd millennium B.C.

4. Zawar mines of Rajasthan 3rd Century B.C.(This has already been discussed in the current chapter).

Additional references on fire setting is also available from the work of Pliny(23-79A.D) *"Natural History"* and *"De Re metallica"* by Agricola published in 1556.

The method of fire setting is more or less same as was practiced at Zawar mines of Rajasthan for lead and zinc mining. Craddock(1992, p.145) summarises the *modus operendi* in the following sequence :

> In essence, a substantial fire was built on, under, or against the rock face, lit, and left to burn itself out. A combination of the differential expansion of the rock and the vaporisation of entrapped water and water of crystallization created great internal stress which caused the rock to crack and shatter. The method was particularly successful against hard, adamant rock that could not adsorb the stresses; it was of little use against soft rock which anyway could usually be mined directly. Only in exceptional cases would it have been possible to approach the fires after they had been lit; the narrow winding galleries of most mines would have been quite impassable when filled with smoke and poisonous fumes. If the still hot rock face was doused afterwards (the evidence for this is discussed below) then it seems likely that this was usually done to cool down the unbearably hot rock rather than to cause further cracking.
>
> Fireset workings are very distinctive. The rock face tends to be smooth and in general to show few tool marks : this is because the rock tends to peel off in flakes parallel to the face. The profile of fireset workings tends to consist of smooth continuous curves, which are quite often sinuous, with few abrupt changes of angle, sharp projections, or cavities where the flames flowed over the surfaces. The other tell-tale evidence of firesetting in underground workings are the deep layers of ash and partially burnt wood-sometimes to be measured in meters on the floors of large mines-and smoke-blackened roofs.

> The method was in use from the inception of mining and quarrying, and would have suggested itself as a method to anyone who had observed the fate of a hard rock incorporated in a hearth. Firesetting was in use before the metal ages in the quarries where hard metamorphic or igneous rocks were obtained for the production of stone axes in the Neolithic period...
>
> Fire setting reigned supreme until the introduction of gun powder in the 17th Century, and even then it continue to be widely used, specially on very hard rock, right upto the end of the 19th century.

5.2 METHOD OF WINNING PRIMARY GOLD

The technique required for separating gold from the ore is very simple, specially when it is free gold (those which are not associated with sulphides). Separation in such cases becomes easy. The same is not true for either base metals or iron, which demands pyrometallurgy to recover the metal from the ore. Thus, base metals demanded elaborate processes of treatment of ores. It is for this reason wherever iron smelting has been carried out, we frequently see evidences like tuyere, crucible, slag, slag mound etc. similarly,copper and zinc metallurgy required enhanced heating process by proper fuel, for instance, in order to extract zinc from its oxide, it was necessary to maintain the temperature of 1150 to 1200° C. This needs employment of suitable refractory material (However, this is not the case for large scale production of gold). In case of copper smelting roasting becomes pre-requisite to convert copper ore into mineral in order to get copper oxide before crushing. The crushed material needs to be treated by gravity separation to remove the gangue material. The process of winning gold did not demand complicated technology or greater metallurgical skill. Perhaps, what Forbes observed holds good for not only to Nubia but also to the entire world.

Forbes mentions (1950, p.30)

> There is little chemistry involved in the production of gold, however, in principle, the metallurgist has only to crush the gold bearing ore and concentrate the gold particles by washing, leaving the useless gangue residue to be thrown away.

> The gold particles would be subjected to melting and cast into rings or bars for trading. This was, in effect, the scheme of gold metallurgy until well into historical times. Apart from a few districts in Asia Minor and other places in the Caucasus, the main supply of gold in antiquity came from the Egyptian deserts of Nubia, where the quarries and mines were worked from earliest times by slaves and captives under the supervision of the army. Often expeditions were sent out to prospect for gold; we even possess a map of such a temporary mining settlement of about 1500 B.C.

But small scale refining of gold was in vogue since 1500 B.C. However, such refining did not demand large scale use of retorts, tuyere and hence slag mound need not be expected as in the case of iron, copper and zinc smelting

Kautilya in his *Arthasastra* (300 B.C) has described the process of purification of gold by using cowdung in Chapter 13, section 3 under the heading "The Superintendent of gold in the Workshop". (Kangle, 1972, p.11)

> Of the best (variety), i.e. gold the pale yellow and the white are impure.
>
> He should (Superintendent of gold) cause that because of which it is impure to be removed by means of lead four times that quantity
>
> If it becomes brittle by the admixture of lead he should cause it to be smelted with dried lumps of cowdung.

The fact that gold crushing was carried out on a very large scale is amply demonstrated at or near the ancient workings for gold in almost all the schist belts. Even today, a large number of pounding marks, crushing stones are to be seen scattered near the ancient workings.

Maclaren (1906) has recorded a large number of crushing stone around the ancient mining sites of Gadag schist belt, notably around Sangli and Kabuliyatkatti areas.

5.3 A BRIEF REVIEW OF METHOD OF GOLD MINING

1. Irrespective of nature of auriferous hard rocks, fire setting and quenching techniques were followed in most of the deep workings in Karnataka and is true for other gold mining in the rest of the world.

2. The depth to water level was the main constraint for progress of mining. Ancients have solved this problem by dewatering the mine and is evident by the occurrence of many pots both fresh and broken which have been recovered from Hutti and Kolar ancient mines.

3. Ropes were used for hoisting men and material, wherever the mines were deep. The rope marks on the main pillars and walls are seen in Hutti workings.

4. In most of the mines Babul and Acacia were used for pillaring.

5. Use of iron gouges (chattis)by the ancients is frequently noticed both in Kolar and Hutti mines.

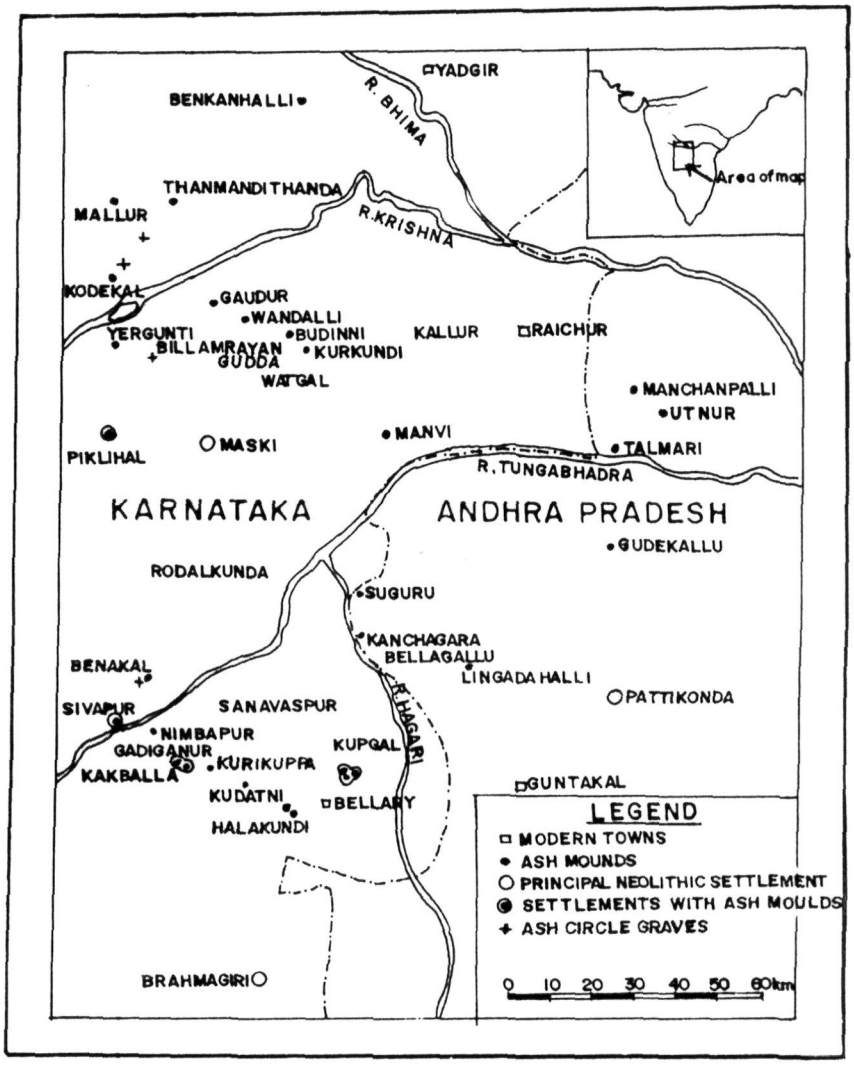
6. Crushing of gold ore was carried out by using stone crushers and some time by using small rock pestels and are seen scattered around many of the ancient old workings.

Chapter 6

ASH MOUNDS AROUND GOLD FIELDS AND THEIR RELEVANCE TO PREHISTORIC SETTLEMENTS

Gold may be obtained either pure or amalgamated with mercury and silver or alloyed with other impurities as mine gold *(Akarodgata)*

- Kautilya (300 B.C.)



MAP SHOWING DISTRIBUTION OF ASHMOUNDS AND MAIN NEOLITHIC SITES.
(After F.R. ALLCHIN 1963)

Fig-60

Ash mounds have wide geographic distribution in Karnataka and adjoining Andhra Pradesh. Eversince Col. Mackenzie reported ash mounds from northern Karnataka, particularly in the Doab Region (Between Thungabadra and Krishna rivers) in the early 19th century, large number of ash mounds have been described by the archaeologists. Particularly, from Belgaum, Bijapur, Gulbarga, Raichur, Bellary and Chitradurga parts stretching from Bhima - Krishna to Thungabadra regions. Though more than 50 ash mounds have been described from Karnataka alone, those clustering around Raichur arouse much interest, since they are nearer to the gold mines. Hence, these ash mounds have been examined by archaeologists and geologists. to understand their relevance to ancient method of gold extraction. (Fig.6.0)

6.1 ORIGIN OF ASH MOUNDS

Opinion is divided among the historians and archaeologists regarding the origin of these ash mounds.

Capt. New Bold (1843) assigned ancient funerary origins for ash mounds of Sangankal near Bellary, while, Robert Bruce Foote (1887) suggested accidental cowdung burning by the Neolithic folk giving them the name Neolithic cinder camps, particularly referring to Bellary ash mound. (Kudutani). Longhurst (1912) based on the occurrence of alternate layers of slag like cinder and ashy earth mixed with fragments of calcised bone remains but recovering no pottery, endorsed the view of Robert Sewell that, it could possibly be the result of a great sacrificial holocausts similar to the ones near Nimbapura, perhaps belonging to Vijayanagar period. He based his argument on Kudatani ash mound of Bellary. Capt. Leonard Munn(1934) studying Gaudur and Wandalli ash mounds of Raichur Doab was skeptic about the Neolithic origin of ash mounds while not convinced by his own thinking that, it could be from spring deposit, he grouped ash mounds of

Wandalli, Gaudur, Benkal, Putkandodi and Yergunti, Lingasgur under iron age.

The work of Gulam Yazdani (1935) on Benkal ash mound has assigned the ash mound to iron smelting site and has opened a new line of thinking. This was followed by the excavations of Palavoy in south western Andhra Pradesh, where, undoubted iron smelting site has been described by Rami Reddy (1976).

Similar view has been expressed for the ash mounds of North Karnataka, specially, in the Krishna valley where based on red pottery of Salvada type and occurrence of iron-age tombs the origin is assigned to iron smelting activity by Sundara (1971).

The excavation carried out by Mujumdar and Rajguru (1966) in the Kupgal ash mound has yielded interesting results. Since most of the ash mounds are vitrified and porous, it is observed by the workers that it requires 1250°C for cowdung to finally convert into vitrified type.

In Raichur alone 12 ash mounds have been described by Rami Reddy(1976). The list includes Benkal, Shivapura, Piklihal, Lingasgur, Rajulbuda, Gorkal, Wandalli, Yergunti, Kurkudi, Gaudur, Budini which are known for Neolithic/Megalithic settlements.

From the point of view of proximity to the ancient mines, it is Wandalli and Gaudur ash mounds which have attracted the attention of geologists and archaeologists alike.

6.1.1 Wandalli ash mound

Wandalli ash mound is located at about 10 km east of Hutti and is about 120 m. northwest of Wandalli village. It is surrounded by a number of ancient workings. Ash mound is right over the cultivated ground on black cotton soil.

The total volume of the ash mound, when first studied by Munn (1934) was little more than 175,000 cu.ft (53,340 cu.m.). The fragments of ash mound has been substantially removed by the locals, with the result, now the volume is considerably reduced. This is evident by the fact that large fragments occur in the bund constructed for the cultivated lands, when the author examined the site.

The ash mound was first described by Foote and the results were published later in 1916. (The Foote collection of Indian Pre-historic and proto-historic antiquities - Notes on their ages and distribution - page 95).

He opined that this heap was formed due to accidentally burnt cowdung. This is reflected in the higher SiO_2 % (66.19%). The analysis of Bose Worth Smith also quoted by Foote almost confirms to the same conclusion(SiO_2 53.10%). Foote drew attention to the samples containing vitrified skeletons of grasses and perhaps even millets(Allchin, 1963).

Munn in his subsequent visit studied this ash mound. He felt probably it could have been the result of some spring giving calcareous deposit. Consequently he revised his opinion (1934) and inclined to think if they were related to some metallurgical processes connected with adjacent gold workings at Wandalli, which he rejected himself in the later years. J.J.Modi in his paper entitled "Recently discovered ash mounds" (1931, presented in Anthropological Society, Bombay) suggested that these ash mounds could well be cremation grounds. Surprisingly no human bones have been recovered from the mound. On the contrary, large quantities of stone hammers, grinding stones, stone pestle and mortars were recovered from the heap (**Plate 14-15**). Subsequent analysis of Wandalli ash mound by Macleran also indicated a very high percentage of SiO_2(66.19%). The slagy nature of the ash mound at some part was thought to be relics of iron or gold smelting. (**Plate 16-18**)

A detailed study of Wandalli ash mound was carried out by Allchin (1963) who firmly established the origin of these mounds to the burning of cowdung. Not only the high percentage of SiO_2 but also the remnants of unburnt straw in the vitrified ash suggested the source to be cowdung. The slagy nature - he attributed to the temperature in the range of 1200 -1270° C. He also carried out the analysis of modern cowdung and the SiO2 percentage was almost matching.

In the course of examination of Wandalli ash mound for the present research work, the author collected 8 samples drawn from different parts of the mound which includes the slagy layer on the top of the mound. There is no preferential stratification in the ash mound and the scoriaceous and slagy samples have common oxide chemistry. Both the varieties show high SiO_2 and Fe_2O_3 percentage. ($Fe_2O_3$2.45 to 3.17%) The inference that can be drawn from the Chemical analysis is that the ash mound does not represent any iron or gold smelting site. As far as major oxides are concerned, the samples analysed by the authors agree well with those of Smith and Macleran's. Only with regard to K_2O the samples seems to be having in higher proportion. This may be attributed to contamination by outside source. As far as SiO_2 is concerned, there is a perfect agreement with the analysis carried out by earlier workers.

Allchin firmly believes that this ash mound is a product of cowdung burning and belongs to Neolithic period. This is further confirmed by the C^{14} dates obtained from Utnur (2170 B.C.) and Kodekal (2335 B.C.) ash mounds taking us back to the earliest phase of Neolithic period (Gururaja Rao, 1979). Further, Gururaja Rao opines that the wide spread pastoralism prevalent in the age was responsible for such huge accumulation over a period of time which was intentionally burnt at certain times.

In the absence of crucible and slag from this mound and based on the result of the chemical analysis specially high SiO_2 percentage, it is justiafiable to assign the origin of this ash mound to cowdung burning in the Neolithic period.

Table - II. A COMPARATIVE CHEMICAL ANALYSIS OF WANDALLI ASH MOUND

	W.E. Smith R.B. Foote, 1916	M. Macleran	Zenner Allchin, 1963	T.R. Anantharamu, 1995 (present work)										
Sampl.	1	1	1	1	2	3	4	5	6	7	8	9	10	11
SiO_2	53.10	66.19	56.88	53.27	65.37	65.15	66.94	61.83	65.52	64.54	61.16	61.02	62.60	56.31
H_2O	0.20	0.26	-	-	-	-	-	-	-	-	-	-	-	-
CaO	10.89	15.88	10.32	10.53	11.04	10.73	10.93	10.02	11.73	11.51	12.20	12.07	11.80	17.56
Fe_2O_3	17.27	-	3.37	2.67	2.45	2.45	2.59	2.47	2.66	2.79	3.17	2.94	3.01	17.57
Al_2O_3	4.51	8.19	5.48	4.63	4.52	4.54	4.16	2.77	4.32	5.05	5.59	5.47	5.19	
Mn_2O_3	-	-	0.10	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	
P_2O_5	1.17	1.57	-	-	-	-	-	-	-	-	-	-	-	2.46
K_2O	1.11	-	5.50	5.14	5.17	5.02	4.40	4.98	4.16	4.56	4.55	5.50	4.70	1.54
Na_2O	2.54	4.52	2.84	2.69	0.89	0.77	0.86	0.75	0.75	0.77	0.72	0.83	0.95	0.86
MgO	3.89	-	4.54	4.83	4.94	4.86	4.89	3.89	4.65	4.91	5.22	4.84	4.41	0.35
Co_2	5.30	-	-	-	-	-	-	-	-	-	-	-	-	nil
L.O.I.				13.30	13.69	5.97	5.73	4.90	5.11	5.59	6.25	5.92	5.45	5.98

Chemical analysis by Atomic Absorption spectrometry, AMSE Wing, Geological Survey of India, Bangalore.

6.1.2 Use of mercury for amalgamation

Munn's observations on the discovery of mercury during panning from the crushed crucible from near Wandalli merits a special attention. Munn records (1943, p.77):

> "Mr. Gray and I got traces of mercury in panning some crushed crucibles from near Wandalli. Lately Dr. Mahadevan got mercury, panning samples at Honkuni. In neither of these cases could the mercury be traced to dirty apparatus, and as Sir. John Marshall reports that cinnabar has been found at Mahenjo-daro, which dates back to 3000 B.C., there seems quite a likelihood that the ancients knew the use of mercury.

This is further confirmed by the discovery some years ago of gold plated minute silver rings in a prehistoric grave near Maula Ali seven miles north of Hyderabad.

The author in his recent visits to Hutti Gold field had the opportunity of studying the collections of Hutti mines, which in its collection has a small crucible recovered from Wandalli area. The size of the crucible is very small and is suggestive of gold smelting as is being used by the present day gold smiths. Since Munn records recovery of mercury from crushed crucible, little doubt exists that these were used for gold smelting on a small scale. Further, Allchin notes(1962) that small scale local extraction of gold was already taking place during Neolithic period.

Use of mercury (for amalgamation) dates back to third century B.C. and well indicated by Kautilya in his renowned book *Arthasastra.*(Shamasastry, 1967, p.91) In Chapter 13, under the heading " superintendent of gold in the goldsmith's office", Kautilya clearly states :

> Gold may be obtained either pure or amalgamated with mercury of silver or alloyed with other impurities as mine gold *(Akarodgata)*, mercury is referred by Kautilya as *Rasaviddha.*

In alchemical literature, mercury has different names and *Rasavadhis* call it the king of *rasas. parada, rasa, maharasa, rasendra, swarnakaraka, sarvadhatu, sivji, harabija* are some of the names by which mercury is referred (Subbarayappa, 1971 - page 318).

Again under the heading "Starting of mines and factories" Kautilya insists that the Director of Mines being conversant with Science of (metal) veins in the earth and metallurgy, art of smelting and the art of colouring gems or having the assistance of experts in these, and fully equipped with workmen skilled in the work and with implements, should inspect an old mine by the marks dross, crucible, coal and ashes, or a new mine, where there are ores in the earth, in the rock or in liquid form (*Rasapaka*)with excessive colour and heaviness and with a strong smell and taste (Kangle, 1972, p.105).

It is obvious from the writing of Kautilya that already there existed old mines, and crucibles were used for smelting. In addition, mercury was used for this purpose as indicated by the name *rasapaka* hence, the report of Munn that mercury was recovered from the crushed crucible may not be a strange case and could only indicate that as early as 3rd century B.C. gold was being treated with mercury in the process of smelting.

6.1.3 Gaudur ash mound

Gaudur ash mound lies about 8 km. N.W. of Wandalli, and immediately north of Gaudur village, on Gaudur-Machanahalli track. This was first visited by Boseworth Smith and subsequently the chemical analysis of the ash samples from this mound was presented by Bruce Foote(1916). The detailed account of ash mound by Munn is available in the annual report of the Hyderabad Archaeological department, wherein Munn has mentioned a total volume of 200 ft. X 50 ft. and 25 ft (76,200 cu.m) on the southern face tapering to 8 ft. on the northern side of this ash mound. Modi(1931) considered this mound also as cremation ground. At the time of Munns visit, the entire mound was already being dug for white washing by the villagers. Interestingly, no human bone was recovered from this heap. Today, the size of the mound has been considerably reduced, no more than a meter and a half exists and perhaps in a decade or so there is no wonder if it leaves no trace of its existence. Kankary boulders have been removed from in-situ and have served as material for the dykes for the cultivated ground (mound is well within the cultivated field). **Plate 19**

In the course of present investigation, the author has recovered a large grinding stone made of pink granite, some bovine bones which have thin calcium coating.

Munn(1934) based on the discovery of big cattlebone postulated if the mound represents scenes of Aryan horse sacrifice(*Ashwamedha yaga*) but was skeptic about the size of the mound and concluded that such a proposition is untenable. By deducing he strongly felt that it does not represent remnant of glasswork, since there is a total absence of crucible and broken bangles.

Different sequence of the ash mound (cross section) given by Munn is as follows:

Typical pale Creamy ash - 23 "
Pink brown sandy layer - 3"
White powdery ash - 12"
Regular layered bands of about 1" thick of darker, earthy material containing charcoal, stones, bones, pots herds etc. - 12"
White loose ashy layers which stones embedded-30"
Ash mound continues down.

Details of identification of bones has been provided by Allchin (1960). From the list, it is evident that more or less all the bones recovered represent bovine.

Allchin, after studying the sherds, he assigned Neolithic period for this mound, while, the bovine bones like in Piklihal were cut in order to extract the marrow.

What is more interesting in Gaudur ash mound is the presence of more slagy ash, which at the first sight can easily be mistaken as the product of iron smelting. Surprisingly, the analysis reveals the same chemical composition like that of associated ash, specially, the SiO_2 % agrees with other ash samples analysed from Wandalli mounds.

The process of how slag can be formed by burning the same stuff is clearly demonstrated in a letter from Superintendent of Hyderabad Gold Mines, while commenting on the analysis (Allchin, 1963, p.82).

He records :

> The fact that the glass and the ash are similar in composition may of course be a coincidence, but I must say that I prefer the idea that they were formed simultaneously from the same original material. This could easily happen in a large pile of stuff being burnt, the glass being formed only in the hottest form of the fire.

It is interesting to note that, here also the ash samples have indicated SiO_2 of 66.3% and CaO 10.5% and thus well correlate with the samples from Wandalli area. However, Gaudur ash mounds have 3% CaO. Perhaps this would have been contributed from the bones present in the mound.

Table III. CHEMICAL ANALYSIS OF SLAG FROM GAUDUR ASH MOUND

(Samples collected by the Author)

GUD/Mach	1	2	3	4
SiO_2	68.37	65.81	69.99	68.33
Fe_2O_3	2.85	2.74	2.92	2.61
Al_2O_3	5.30	4.57	4.08	4.75
TiO_2	0.20	0.20	0.20	0.20
CaO	11.26	10.54	9.79	10.51
MgO	4.49	3.96	3.52	4.08
Na_2O	1.21	1.15	1.08	1.21
K_2O	4.96	5.09	6.02	4.80
MnO	0.10	0.09	0.09	0.09
LOI	2.19	1.84	1.09	1.17
Au	<10ppb	<10ppb	<10ppb	<10ppb

Explanation GUD = Gaudur - Mach = Machanahalli
(Chemical analysis by AAS method, Chemical Laboratory, Geological Survey of India, A.M.S.E. Wing, Bangalore).

Chapter 7

NEOLITHIC SETTLEMENTS IN RAICHUR DISTRICT AND GOLD MINING ACTIVITY

You have to choose (as a voter) between trusting to the natural stability of gold and the honesty and intellegence of the members of the Government. And, with due respect for these gentlemen I advise you, as long as the capitalist system last to vote for gold

- Bernard Shaw

Protohistoric and prehistoric findings from Raichur Doab have contributed in a large way to our understanding of the early settlements in this part of Karnataka. Since they have a bearing on the mining aspects of gold, Neolithic settlements in Raichur district are of special interest.

Between Yadgir on the north of Bhima river and Brahmagiri on the south of Tungabhadra more than 25 ash mounds have been described by Allchin (1963). The principal Neolithic settlements are Maski, Piklihal, Billarayana hills, Anandgal, Kotekal, Watgal which have been described by Foote, Munn and Allchin in great detail. In addition, in Yemminagudda near Kallur, in Manvi taluk, ash, broken pieces of crucibles, crushed quartzite, mealing stones and traces of copper have been reported by the Archaeological Department of Hyderabad between 1937 and 1940. These findings have a great significance from the point of view of metallurgy. This needs to be explained taking into consideration the Neolithic settlements and subsequently the iron age culture of this part of Doab.

7.1 THE IMPORTANCE OF NEOLITHIC SETTLEMENTS

The importance of Neolithic culture and its effect on the early settlement is explained by Gururaja Rao (1979, P.49)

> The Neolithic or new stone age culture prevailed in South India from about the middle of the third millennium B.C. The people of this culture were responsible to bring about the sedantic life in this part of the country. There is an abundance of evidence in the region for the habitation of the region in earlier times by the food gathering people who belonged to the mesolithic stage of economy. But probably inspired by the happenings in West Asia and particularly in Iran and their echo in the Indo-Iranian borderlands, these people appeared in Deccan, more specifically in the Raichur-Bellary belt of Karnataka rather abruptly...
>
> they started manufacturing domestic utensils like pottery, tools, and implements like polished or ground stone celts, chisels, ring stones, adzes, fabricators and hammer stones, flaked blade-tools of the microlithic order etc..
>
> The basaltic and doleritic rocks available there could be utilised for tool making. They lived in cave-mouths or under rock-shelters; probably at a

comparatively later period, they erected circular huts of wood and wattle circumscribed by a circle of huge boulders.

7.1.1 Prehistoric sites of Raichur area

From the point of view of early settlement, Benakal prehistoric site has gained more attention. Specially, here rock paintings depicting hunting scenes in which men are riding both ponies and humped cattle have been recorded by Munn(1934). In addition, dolmens with portholes have been described from this part. Rock brusings from Billarayanagudda have added to the knowledge of prehistoric culture (these have been described by Khwaja Mohammed Ahmad - Note on the excavation and survey of pre-historic site of Raichur district of Hyderabad - Annual Report of Archaeology, H.E.H The Nizam's dominions for the year 1935-36 page 28; L.Munn Prehistoric and protohistoric finds - The Journal of Hyderabad Geological Survey, pt. I pp.130-131, 1934).

Besides, the occurrence of minor rock edict of Asoka in Maski hill has gained a lot of importance from the point of view of spread of Buddhism. Moreover, the site of Asokan edict is very near to the famous Maski gold mines. This has been described separately in Chapter 8.2.1 dealing with Rock edicts of Asoka.

The earliest archaeological examination of Maski area was carried out by Bruce Foote between 1870-1888. He added many more stone implements to the collection from this part. Subsequently Munn between 1928-29 followed by archaeological department of Hyderabad undertook extensive survey of Hutti-Maski area and added many more findings. They include terra-cotta cylindrical seal (An. Rep. Arch. Dept. H.E.H.The Nizam's dominions for the year 1936-37 - page 15). The excavation carried out by Thapar (1954) of the ancient site located to the west of Maski village rising

above 400 feet from the plain has unearthed a chalcolithic site (1000-400 B.C.).

All this clearly demonstrate that this part of the Doab is rich in Neolithic settlements and at least in the beginning stage of the search for yellow metal, this settlement becomes all the more important.

7.1.2 Earliest gold objects from the Deccan

The excavations carried out at Tekkalakota (15°12' N -76°53' E) a town in the Siruguppa taluk of Bellary district, Karnataka, has brought to light two phases of Neolithic culture. Phase I is characterised by the potsherds, stone axes, blades of chert, chalcedony and rarely opal, gold objects, beads of steatite and semi-precious stone, bone tools and copper axe. Phase II is characterised by copper objects, microliths, ground axes and beads and is of typical chalcolithic period.

Gold objects described from phase I includes

1. A gold pendent or ear ornament with three coils in the centre and trumpet - mouth shaped, solid terminals, ending in opposite direction and weighs 7.49 g.

2. A similar ornament but with one of the ends broken. The ends are somewhat flattened and the coils in the center are more in number and weighs 5.37 g. (Nagaraja Rao, 1965). The occurrence of gold ornaments in Tekkalakota may not indicate the source of gold. However, one cannot overlook the proximity of the place to the gold mining area. It is also to be noted that one cannot tell with certainty if these objects owes their source to gold mines of Kolar or Hutti. In fact, Kolar is about 220 km south of Tekkalakota and Hutti is 65 km. north of it. From the proximity point of view, Hutti looks

to be a more probable source. However, as already described the Konganahosur and Chigateri areas of Bellary district have known for placer gold sources in a stream. This aspect has been described in the chapter dealing with panning of gold. (4.1.3)

Nagaraja Rao (1965) after carrying out extensive investigation in Tekkalakota concludes that the occurrence of gold objects in considerable quantity in the limited excavations and the proximity of gold workings and mines indicate the possibility of being locally manufactured. Nevertheless, Tekkalakota findings pushes the use of gold in the Deccan to 2000 B.C.

Chapter 8

MEGALITHIC CULTURE AND ITS IMPORTANCE IN MINING

In every species of gold there is a proportion of silver in some one tenth part, in others a ninth and in others an eighth

- Pliny, the Elder (79 A.D.)

The megalithic culture was the earliest known culture for introduction into South India, a full pledged agricultural economy based on irrigation. Iron which makes rather a sudden but wide spread appearance arrived either with the megalithic culture are closely followed it. The end of chalcolithic culture in central and western India and the Deccan occurred about 800 to 700 B.C. as suggested by C^{14} dates (Gururaja Rao, 1972). The influence of iron age, more particularly on South India is aptly described by him in the following words :

> Though the discovery and use of iron came last in the inventory of the basic metals by man, coming as it does after copper, tin, lead and many of their alloys, it marked one of the greatest milestones in his progress. So far as South India is concerned, iron is the first metal to influence, to any extent human life which was lingering on in the stone age economy for thousands of years. Copper, bronze and gold which might have been used earlier than iron, played, if they did only a very insignificant role in human affairs in South India....
>
> Though the iron ores were comparatively widely distributed in the old world, the discovery of iron smelting was delayed by the primitive condition of furnaces which produced sufficiently high temperatures to smelt copper ores, viz. about 1100°C, but iron needed as high a temperature as 1535°C for the ores to smelt into a liquid and readily forgeable state while little solid grains of iron could be obtained at such low temperature as 700-800°C. Again while molten copper could be poured into moulds to obtain the required objects, the iron obtained from the ores at high temperature was a soft spongy material which had to be admixed with carbon in proper proportion to obtain sufficient sharpness and hardness. Further, the impurities present in the ores had to be removed by using a catalytic flux such as lime to produce this slag (p. 257-258).

The changes that were brought about the impact of iron age culture on neolithic and chalcolithic community and the introduction of iron is explained by Narasimha Murthy (1989, p.18) :

> Iron changed the entire concept of urbanisation. Small and compact neolithic-chalcolithic communities underwent a change beyond recognition. The growth of big urban centres was simply accelerated by the introduction and the use of iron as an important metal. Iron provided not only hard and sharp tools of his daily needs but made him conscious of rudiments of defense even offense against the enemies. Here this metal was introduced by those people who built megalithic stones and hence

called as Megalithic culture, whereas in north, iron using communities do not have this lithic. Thus, in Karnataka, megalithic culture is synonym of iron culture..

Karnataka is literally dotted with megalithic burials which fall into various types. Whatever is the exterior difference of typology of the megalithic burials, they have a common trait and that is the presence of iron object. Those megalithic people believed and practiced a type of religion in which they buried along with the dead, things that were used by that person, obviously for his future journey. That includes pots, pan and iron objects...

The megalithic people manufactured a variety of iron tools. They include the following types:

Knives with or without handles, daggers, arrow heads, wedges, spears, leaf shaped lances, axes, adzes, sickles, hoes, hooks, chisels, crow-bars, fringing pans, rings, bangles, bracelets, diadems, pins, nails, spikes, hangers, tripods, rods, javelins, swords, various ornaments and heads. These were used for various purposes.

Considering the advancement made during the megalithic period, attempts have been made by archaeologists to link megalithic culture with gold mining. Notably, hundreds of megalithic tombs have been reported from Kolar area and are not far from gold mines. Munn in the early part of this century, had drawn the attention of historians and archaeologists to the clustering of megaliths on the Deccan where there are ancient workings for gold (Heathcote,1927). Specially, the megalithic tombs adjoining Kolar Gold Field had attracted the investigators.

8.1 Megaliths from Kolar and Hutti gold fields

From Kolar Gold field area, important megaliths have been described 3.2 km. east of Parandapalli and 3.2 km. from the Travellers Bungalow, at Robertson Pet, K.G.F. towards Bethmangala. Here more than a hundred stone circles of varying dimensions have been recorded by Mysore Archaeological Department. Diameter of the stone circles varies from 7 to 40 feet (2.13 to 12.19 m) at the ground level (Krishna, 1941)

Similarly, at Hunugund, 3.2 km. southwest of Hungund patna, on Kolar-Bethmangala road, a large number of megalithic stone circles have been

identified. The diameter varies from 15 to 20 feet (5.22 to 9.14 m) and were in disturbed condition.

One important observation made by the earlier investigators about Hungund is the terminology concerning gold. Mysore Archaeological Report mentions:

The ancient name of Hunagund is Honnukonda meaning gold pit and the ancient Tamil inscription at the place refers to the place name as Ponukundram.(Krishna 1941, p.43).

This has led to think that the megalithic culture must have been closely connected with the gold mining in this area. However, this problem has been dealt in detail by the author specially concerning Dimaldinne (chapter 8.3) which was thought to be gold processing centre. However, mention may be made about the occurrence of megalithic stone circles often of the Dolmenoid cist varieties as reported by Gururaja Rao (1972).

The other areas from where stone circles are described in Kolar district are 5 km. W.N.W. of Kolar on the Kolar-Chikballapur Road (Cole Robert, 1873 page 87) which on digging yielded pottery, iron implements and some time a few bone pieces also. About 3.2 km. west of Kolar on the Kolar - Bangalore road, near Chinnasandra and Konganahalli in Chintamani taluk, one more stone circle has been described (IAR 1955-56 p.70). About 3.2 km. from Bangarpet near Kolar a double stone circle has been described and similarly stone circle ranging in diameter from 13 to 24 feet (3.96 to 7.31 m) has yielded on digging, pottery, iron tools and bone fragments (Cole Robert, 1873 - p.87). Cairn circles have been reported from near Huladenahalli in Malur taluk (Congreve, 1861, pp.205-212).

The linguistic importance of Honnavar has already been discussed. 5 km. northwest of Anguvali, an iron age town and .8 km. south of Hungami

known for placer gold, stone circle varying in diameter upto 20 feet have been described (Krishna 1941).

There are two aspects to be taken into consideration in this context. The obvious clustering of megaliths around ancient mines definitely deserves a place in the gold mining history and the second aspect is the possible contribution of megalithic people for further development of mines by using iron implements. In other words, the iron age people have taken considerable advantage of the advancement of iron technology for gold mining.

Though Munn (1936) describes a large number of megalithic tombs, dolmen etc. from Raichur Doab, he declines to think megalithic people are responsible for gold mining in Karnataka. He advocates that mining, whatever date it started, continued well into the iron age (1300 B.C. ?) Similarly, the work of Gururaja Rao (1972) on megalithic culture clearly indicates that many megalithic tombs are located outside the gold field area also.

If we take into consideration the objects recovered from both Hutti and Kolar ancient mines, the fact remains, that Chattis (iron goges) are also included in the collection. Therefore, the influence of megalithic culture on gold mining cannot be ignored at any cost. In fact, deepening of the ancient workings, would not have been possible without using iron implements and tools specially, in the hard rock terrains like Kolar and Hutti Gold Fields.

8.2 OVERSEAS TRADE AND GOLD SOURCE FROM KARNATAKA - A REAPPRAISAL

The trade links between India and Greece on one hand and India with Egypt on the other hand in the Pre-christian Era is amply indicated in the works of early historians. Notable among them are *History* by Herodotos (484-431 B.C.) *Geography* by Strabo (54 - 24 B.C.), *Natural History* by Pliny (23 - 79 A.D.) as reflected by John W. McCrindle (1979).

As regards gold there is no mine mentioned in or near Indus valley, on the contrary, the historians have recorded plenty of gold obtained from panning the rivers.

From the work of Herodotos, it is understood that Darius (522 -486 B.C), on ascending the throne of Persia divided his empire into 20 governments called *Satrapies* and fixed the amount of tribute which each of these should pay into his treasury. Though, India stood last, in his enumeration of the *Satrapies* but paid a tribute proportionately larger than all the rest - 360 talents in gold dust (McCrindle 1979).

This gold is believed to have been obtained by panning the sands of Ganges (hence the name *Gangeya* for gold) and rivers which drained Jammu (hence the name *Jambunada*).

There are ample references for gold in Vedic literature. According to Brajdeo Prasad Roy (1984), the Vedic people were very much attracted towards it on account of its shining yellow colour. The vedic hymns addressed to the Gods abound with fervent prayer for gift of gold. For a long array of similies and metaphors and luxuriant terminology of *hiranya*, one may easily conclude that the Vedic people had wide knowledge of it. As many as 16 synonyms of gold occur in the Rigveda alone, some of which denote its different varieties. Some of the important terms in relation to gold are *rukma* which denoted ornaments made of gold, *jatarupa*, meant original beauty or form of gold or ornaments made of it, having native beauty. On account of its yellow colour it was know as *Candra*.

The vedic literature mentions gold in connection with rivers. According to him, it seems that they obtained it from the beds of rivers. The Himalayan rivers flowing through the Punjab carried gold dust in their waters which must have attracted the attention of the people. The Rigveda refers to the

river Sindhu as *hiranyani* and *hiranyavarni*. The practice of collecting gold dust from the beds of rivers continued even during the post- vedic times. Herodotos and Megasthanes (302-288 B.C) mention that West India was rich in gold. According to the former, the Indians obtained it by digging the earth, collecting it from the beds of rivers and from the deserts.

According to Amarasimha (4th Century A.D) as many as twenty three words are given for gold as synonyms. They are :

Swarnam, Suvarnam, Kanakam, Hiranyam, Hema, Hatakam, Tapaneyam, Satakumbam, Gangeyam, Bharma, Karburam, Chamekaram, Jatarupam, Maharajatha, Kanchanam, Rukmam, Karthaswaram, Jambunadam, Astapadam, Vasuchandram, Arjunam, Kalyanam and Bhurigairikam.

Further Amarasimha has given thirteen synonyms for money in Sanskrit. They Are :

Dravyam, Vittam, Swapatheyam, Riktam, Rktham, Dhanam, Vasu, Hiranyam, Drvainam, Dyumnam, Artham, Vaibhavam and Raha.

Since many references have been made in the vedic literature for the alluvial gold it stands to reason that the Vedic people obtained their gold from the river-borne sands draining the Himalayan region. Most of the rivers of Punjab, Kashmir and other northwest provinces have been described to yield gold, especially a river named *Jambunada* (probably flowing westwards from Jammu and perhaps joined with some tributary of Sindhu and now extinct), river Sindhu and Ganges. However, it is well known that the pepper and salt sandstone of the Siwalik ranges of the foothills of the Himalaya contain gold in insignificant quantities. The rivers draining the Siwalik Himalayan ranges would carry this alluvial gold which probably won over by the vedic people. Hence it is possible that no mention of gold deposit of great significance has been made in the Vedas (Murthy and Anantharamu, 1992).

Indus valley civilisation had developed metallurgical skill for gold and is reflected in the beads, fillets and other ornaments used by Harappans. It is widely believed that the gold was supplied from the mines from Karnataka. This is indicated in the writings of Wheeler, Rao and others.

Wheeler (1968) firmly believes that the gold may be washed from the sands of many of the great rivers of India and is abundant in the south, particularly, in Mysore state where it is mined. It occurs also near Khandahar and elsewhere in Afghanisthan. The gold used for beads, fillets and other ornaments by the Harappans may thus have come at least in part through trade channels, some of its probably from south India.

Rao has worked out different trade routes through which chalcolithic economy of the Indus civilisation flourished by way of importing metals, minerals along with other commodities from different areas. Rao also mentions the possibility of gold being imported by Lothal (p.116) :

> Lothal as well as the Indus valley cities received gold from the Kolar and Hatti gold mines in Mysore State. The occurrence of typical Harappan products such as disc-beads of white steatite at Maski, Piklihal, Tekkalakota, Utnur(2300 B.C.), and flat copper celts at Tekkalakota (1700 B.C.) and Hallur, all situated within the gold-producing region of Deccan assumes great significance in the present context. Recently some neolithic sites have been discovered in the ancient gold-working region around Kolar in Mysore State and Hosur in Madras State. It is not improbable that the gold from Kolar and Hatti mines was carried over land and sea routes through one of the ancient ports situated on the west coast mentioned by later Greek Writers. The very name *Honnavar* associates this port with trade in gold. Further coastal survey south of Bombay right upto Calicut is necessary if we have to trace the extent of overseas trade in the third and second millennia B.C. We know, for example, a particular kind of wood namely *Santalus* reached Rangpur from the Malabar forests in the second millennium. Silver was used sparingly by the Harappans. Except for a bangle and a couple of indeterminate objects the precious metal is rare at Lothal. If the gold-miners of Kolar region knew how to separate silver from gold they might have supplied both to the Harrappans. Otherwise, the Zawar mine near Udaipur in South Rajasthan is an alternate source for silver and lead. But in view of the high silver content of the gold used at Lothal it is presumed to have come from Kolar...
>
> Agate was imported from the Rajpipla mines on south Gujarat and chert from

the Sukkhur-Rohri area in Sind. Green felspar and amazonite might have come from the Palanpur mines in north Gujarat or Doddabetta in the Nilgiri Hills in south India. Crystal and opal, though rare, were used at Lothal and Indus cities for bead-making, and the source may be Coimbatore in south India. Among the varieties of crypto-crystalline silica, onyx was valued very much by the lapidaries of Lothal. The only known source of this material in Kathiawar is Vijarkhi near Narmada, a Harappan site in Saurashtra.

Not only the silver content of the gold that matches, even the other ornaments used by Indus civilisation is remarkably identical with those described from different chalcolithic sites of Karnataka. Rao may be quoted here (p.116) :

> The disc-beads of burnt steatite found in the Chalcolithic-neolithic sites of Mysore-Andhra region are identical with the Harappan wafer beads. Perhaps the neolithic people of Deccan supplied steatite and gold in return for copper tools and beads of gemstones to the Harappans. In this connection the occurrence of parallel-sided blades of stone, and evolved Harappan ceramic types in a black-and-red ware at Singanapalli, Pusalapadu, etc., in Kurnool district is highly significant.

Hence, it could only be a probability that Harappans have obtained gold from the South Indian mines.A word of caution has been spelt by Rajni Nanda (1992) regarding the source of gold to the Indus valley civilization which merits attention (p.199-200) :

> The problem of the source of gold during the mature Harappan period is more interesting. It is generally thought that the Kolar field could have been an important source in this context. What possibly is meant is that the entire auriferous ore from Raichur to Kolar, Wynad, etc. could have supplied gold to the Harappans. We would not deny the possibility that this belt could be a source of gold for the Harappan sites in Gujarat, but we find it difficult to accept the idea that the southern belt was supplying gold to the mature phase of the Indus Civilization representing at such sites as Mohenjo-daro, Harappa and Chanhudaro. The point is that we hardly have any evidence of contact between the mature Indus sites in the Sindh and the south Indian Neolithic sites. This is a point which is not always remembered when the southern field is suggested as a source of gold for Mohenja-daro, Harappa, etc. The alluvial gold was undoubtedly was a source and the collection of alluvial gold has been recorded for the North-western Frontier area and Punjab.... The southern belt could have come into operation as early as the southern Neolithic period beginning in the middle of the third millennium B.C. But there is no positive proof for such an early date, a more probable influence would be that its use began in the second millennium

B.C. as suggested by the finds at Tekkalakota. It is only in the megalithic and the early historic periods that the importance of the southern field really increased.

The analysis of gold by metallurgists has clearly indicated that pure gold does not occur in nature, on the other hand, some part of silver, copper or iron normally gets amalgamated. In addition, gold may contain a small percentage of titanium, lead, aluminum, antimony, mercury, vanadium, bismuth, manganese, silicon, arsenic and tin. Normally the purity of gold is defined by fineness and is expressed as the ratio of gold to some of the gold and the silver in the naturally occurring alloys and is defined as 1000 time.

Gold which carries silver in part is referred as electrum. The exact proportion of the silver in the gold is not precisely fixed by the metallurgists. Some calculate that the electrum of the ancient times consisted of 73% gold and 27% silver. According to one more definition electrum should have 67.3% gold and 32.7% silver. It is remarkable that ordinary reef gold gives just about these proportion of gold and silver (Mervyn Smith, 1892).

The silver content of the gold from both Kolar and Hutti have been studied by different metallurgist and these range from 875 to 920 fineness.

It is evident that Kolar and Hutti reef gold can be categorised under electrum. Metallurgical analysis of artifacts to trace the source has been tried by many workers, particularly by using electron microscope it is possible to study platinum group metal inclusions in the gold artifacts (Ogden, 1977). X-ray Fluorescence spectrometer have been employed by Meeks and Tite (!980) to study platinum group association in gold jewellery and coins. Analysis of platinum group elements have not proved to be of great help since mere presence or absence of platinoid minerals may not indicate any particular source since there could be variation in the concentration level within the deposit. Warren and Thompson (1944) have determined the

concentration of 17 minor elements in gold from 66 source deposits throughout the world. The result has shown some significant variation from region to region.

This method seems to be of great advantage but requires a large number of analysis from various source; both primary and secondary gold.

Therefore, in order to determine the source of gold supplied to Indus civilization, it needs minor and trace element analysis of the gold artifacts as well as gold from the suspected source.

8.2.1 Rock edicts of Asoka and Gold mines

There are, in all 23 rock edicts of Emperor Asoka (273 to 232 B.C.) distributed over the entire country. The geographical locations of many of these edicts, have arouse curiosity particularly from the point of view of proximity to metallic mineral deposits and more particularly the ancient gold mines.

Asoka's message of love and human piety is inscribed in rocks, pillars and caves and are named accordingly. Asoka's empire comprised the whole of India excluding part of Tamil Nadu and is stretched even upto the present day Nepal, Bangladesh, Pakisthan and a major part of Afghanisthan. In India, the southern most locations of the rock edict are the Siddapur edict (Yemmethammanagudi), Jatinga-Rameswar edict and the Brahmagiri edict in Molakalmuru taluk. It is only in the Brahmagiri edict, the name *Suvarnagiri* appears.

Maski, which from an important gold bearing belt in the Maski-Hutti tract possess one important minor rock edict. It is only in this edict, the name Asoka is inscribed.

The renowned book *Arthasastra* of Kautilya, mentions the importance of mines " The treasury has its source in the mines; from the treasury the army comes into being; with the treasury and the army, the earth is obtained with the treasury as its ornaments" (Kangle,1972, p-110).

This throws light on the material interest of the Mauryans. The importance of rock edicts vis-a-vis gold mines is elucidated by Thaper (1980, p.285) :

> Concerning the importance of the site in South India, we must keep in mind that the areas within which most of the edicts have been found tallies closely with the gold mining areas of the south.

Applying this, it is surprising to see that the two Koppal edicts (Palakkigudi and Gavimata) are about 30 km. east of Gadag Gold Mines. However, gold mining activity in Kolar Gold Field, though has been on large scale no edicts have been reported from this part.

Satyaprakash Mishra (1987) has made an attempt to link gold mineralised locations with rock edicts of Asoka and believes that the Mauryans had advanced knowledge of metallurgy including gold and base metals. Mishra writes, that, they are (rock edicts) overwhelmingly concentrated in regions which show ancient gold mining activity. 11 such inscriptions 9 from Karnataka and 2 from Andhra Pradesh (1 each from Erragudi and Rajulmandgiri from Kurnool district) are spread over a small area underlain by Dharwar schist belt in Karnataka and Andhra Pradesh. Elsewhere in the north also (Kalsi, Rupnath and Girnath) a fair correlation is seen between the rock edicts and auriferous occurrences.

Next to gold, lead-zinc-silver-copper occurrences in the areas of Mauryan sites are noteworthy (Kalsi, Bairath). The sites for the edicts might have been chosen by a careful consideration of varied factors. Precious mineral potential of the region seems to be an important criteria. A close

corroboration of the edicts with polymetallic deposits suggests that the Mauryans were familiar with the geological resources of their empire and that they had fairly advanced knowledge of mining and basemetals.

However, not all the edicts are located near the metalliferous mines. For instance, Delhi and Sopara edicts have no geographical entity as far as minerals are concerned. Similarly, Ahraura edict of Mirzapur, U.P. has nothing to do with any gold mineralisation. The fact that the largest number of rock edicts are located in Karnataka draws the attention of historians to a greater extent and Munn, a keen observer in the field, draws our attention to the name *Suvarnagiri* inscribed in Brahmagiri edict. Suvarnagiri might in all probabilities indicate Maski. Munn based on the findings from near Asokan edict comments (1934) that during the last three years that he could find clear evidences of ancient sites of Mauryan date at Maski, Koratagi and elsewhere and in the Asokan inscription at Maski and another near Kollal, all point strongly to a very early era of civilisation in this area. He supposes whether the translation of the name of Asoka's capital in the Deccan *Suvarnagiri*, the golden hill has any significance and again, he points out to debris filled with painted pottery, chank shells, bangles, beads etc. testifying to a site of a forgotten city of Maski. He also mentions that after the rains, the gold ornaments have been picked up near the site and in a site near the cave containing the Asokan inscription and its neighbourhood, he could locate many saucer like depression in the rock and mullakers where apparently gold quartz seems to have been crushed (p.80).

Therefore, taking this into consideration, the extension of the empire of Asoka upto northern Karnataka and the spread of Buddhism certainly has a bearing on the history of gold mining and Maski must have been one of the main centres of this activity.

This supposition gains further value, if we carefully examine the references made by Kautilya in his Arthasastra which gives valuable information about the trade between the north and the south during Mauryan period.

Among land routes, says Kautilya, my teacher considers that leading to the Himalaya superior to the one leading to *Dakshinapatha*, because of elephants, horses, spices, ivory, hides, silver and gold articles all are valuable (to be had there). He then expounds his own quite different view as follows:

No, says Kautilya, although it is deficient in woolen cloth, hides and horses, the *Dakshinapatha* abounds in Conch shells, diamonds, precious stones of other kind, pearls and articles of gold. Moreover, the southern trade route across Dakshinapatha traverses a territory rich in mines and valuable merchandise is frequented by many (traders) and easy to travel by, that is the superior route. The view represented by Kautilya's teacher (Acharya) was becoming rapidly out of date as a result of new conditions, and the pupil affirms of trade in south than even before. The mention of gold, diamonds and other precious stones and pearls and easy conditions of travel along the much frequented routes deserves to be particularly noted.(Shamasastry - 1967, p.81).

The wealth of South India in terms of gold is recorded by Pliny, the great Roman historian (79 A.D.). Particularly his account of Indian geography with description of mountains deserves a special consideration from the point of view of the location of gold mines.

> In the country of Nareae, the mountain Capitalia, there are various veins of gold and silver in which the Indians work very extensively.

Mountain Capitalia, which Pliny refers is now identified as Mount Abu of Rajasthan and the name Nareae is referable to Nair community of Kerala,

where Wynad gold field exists. However, the occurrence of huge number of pestle and marters or pounding stones in the Kolar, Hutti and Gadag gold fields bear ample testimony to a once flourishing mining and metallurgical industry (Ziauddin and Narayanaswamy, 1934)

8.2.2 Influence of Ancient gold mining of Karnataka on the South African mining

Study of gold occurrences in various shield areas of the world, clearly brings out the fact that ancient gold workings are not restricted to south India alone. We have ancient mines reported in thousands in South Africa, specially from Rhodesia and Transvaal. The method of working as reported by South African geologists is almost identical to the workings of Karnataka.

Anhaeusser (1976, p.46) describing the South African gold mines records :

> Just when the early mining of gold by the ancients first began in South Africa remains obscure. Archaeological evidence suggests, however, that mining in the state of Mysore in India may have provided the inspiration for the Rhodesian ancient workings to have developed from 3rd century A.D. onwards. By the time the early European explorers arrived on the scene during the 19th century, the ancient workings of Rhodesia had long been abandoned and largely forgotten.

Ancient mines of Transvaal have been described in detail by Thain (1947). He opines that the Pre European Gold Mining and working in South Africa is a tantalising field for conjecture. From South Africa alone, more than 1000 ancient workings have been described. These are distributed in Rhodesia and Transvaal and Bantu speaking people of both north and south Transvaal have recovered placer as well as reef gold from this part. From Barberton area, ancient shafts and drives have been discovered. There are reports of smelting pits with clay blast pipes in sites containing small

quantities of smelted gold. Some still possess the remnants of charcoal, quartz brass or copper ornaments (page 243).

What is common between South African mines and the ancient mines of Karnataka ? Munn (1936) answers this question and believes that the method of mining followed in both the areas are almost identical. Munn further strengthens his arguments by saying that the tamarind trees (*T. indica*) and wild cotton plants were found growing around these ancient workings in Rhodesia. Neither of which plants are indigenous to South Africa. Further he mentions that in Rhodesia this tree is only found on the areas of the prehistoric rock mines, but the vast extent of the country now covered by forests demonstrates that it arrived in some exceedingly remote times. Being an Indian fruit tree, it was in all probability introduced by Indians (page 107). Though no megalithic structures are reported from the prehistoric sites of Rhodesia, Munn incline to think that the Rhodesian prehistoric mining was done by Indian labour. This he ascertains by quoting similar crushing methods for recovering gold and thus refutes the Egyptian influence on Indian gold mining.

8.3 A CRITICAL EVALUATION OF DIMALDINNE ASH MOUND OF KOLAR DISTRICT

There are many reports pertaining to the ash mound of Dimaldinne of Kolar district. Since, this location is nearer to the Kolar gold mines, the ash mound attracted the attention of archaeologists, geologists and the historians, from the early part of the present century. In order to evaluate the nature of the mound and its relevance to the prehistory of this area, Prof. B.K. Gururajarao, Prof. T.V.Shivarudrappa and the author undertook the investigation of this area and have comeout with many archaeological findings. Both Patna (referred to as Hungund patna in earlier literature) and Hungund

are rich prehistoric sites and are very near to the present gold mines of Kolar gold field.

8.3.1 Investigation around Patna

Background: Patna (lat : 13°3'30" : long: 78°15'00") is a road side village lying 16 km southwest of Kolar and 12 km northwest of Bethmangala on Kolar Bethmangala road and is located on the granitic boulders (Geologically this granite is referred to as Patna granite which intrudes the Kolar Schist belt). Pedestal rocks and hummocky topography are quite characteristic of this area (**Plate 20**). One km northwest of the village, an ancient site has been reported which dates to early Christian era. The archaeological department of erstwhile Mysore has described painted potsherds, plenty of iron slag pieces, pottery spirals, shell bangles from this site. This has been compared with Shatavahana layers of Chandavalli. Besides, several cave shelters of prehistoric man with polished neoliths have been recorded from this site.

Present work: About 500 m southwest of rocky knob .846 and a km due south of Patna, another granitic hill is perched. This hill is locally known as Seethagudda (at the top of the hill a mud fort wall of about a meter thick is built on the boulder, which appears to have been built during the late medieval period). On the top of the hill there are circular depressions nearly 2 m deep are visible quite prominently. From the surface findings, it is evident that it was a rich megalith site. On the slope of the plain surface on the hillock itself large quantity of megalithic black and red ware, black polished ware and also illfired red ware with crude fabric are find shrewn over the entire area (**Plate 21**). At least on two such plain areas, on the top of the hillock, there are early diggings, where, potsherds are found in large quantities and from the section also megalithic potsherds are sticking out.

The examination of potsherds indicates, that the the fabric was very fine, particularly black and red varieties. It was made of levigated clay with a fine fabric and well fired. The thin section would yield metallic sound when tapped. Thus, a mature stage of megalithic culture is evidenced. Side by side with that, we also had cruder black and red ware with coarse fabric.

In more recent time, it appears, that the hillock was fortified probably during Vijayanagar time (Krishna, 1940). The fortification walls were constructed in dry masonry in the earlier period and in the late period, unburnt mud walls were constructed above the dry masonry walls.

On the granitic rocks, a large number of grinding grooves are observed. These might have been used for grinding mortar but some deep circular grooves about 15 cm deep 10 to 125 cm. in diameter are also observed which were definitely used for mortar grinding. (**Plate 22**)

In the wide strip of cultivated land, south west of rocky boulders, a large number of iron slag pieces have been found. This points to undoubted iron smelting site, which existed here. This site has been described by earlier workers as the site of ancient town belonging to early centuries of Christian era.

8.3.2 Investigation around Hunkund

Hunkunda: About 3 km south west of Patna lies another hamlet Hunkunda(Lat. 13°25' : long 78°15') which is also known for its prehistoric settlement. The granitic boulders continue to surface out in this part also. About 600 m east of the village, a granitic hill rises about 800 m from the m.s.l. It is locally known as Pallegudda.

Background: Mysore Archaeological Department in the early forties has investigated the area, specially the ash mound known as Dimaldinne

which is immediately east of the village. The ash mound has been referred to in a number of literary works, particularly in connection with gold smelting activity (Krishna, 1940, Gururaja Rao, 1972, Gururajachar, 1974, Chidanandamurthy, 1966). On the top of the mound, there is an old temple of Someshwara (Chalukya period) and the Tamil inscription near the temple mentions the name *ponnukundram* which literally means golden hill. The antiquity of Dimaldinne is further heightened by the occurrence of large number of cromlechs.

Present Work: Detailed examination of the site on the hillock near Someshwara temple yielded many interesting results. Here we discovered a large megalithic site but most of the burial sites are disturbed but in the crevasses between the rock boulders, large quantities of megalithic pottery consisting of black and red ware, black polished ware are found. A few sherds appear to be burnished variety were also found but, their neolithic affinity was not certain. However, the existence of rock shelters and the presence of dolerite boulders compelled us to search for polished stone implements(neoliths). Hence, our intense search resulted in finding a broken polished celt near the steps of Someshwara temple. Further search yielded one more polished celts of the round butt type, unfortunately broken at both the edges. But its neolithic affinity was unmistakable (**Plate 23**). In addition, some more broken pieces of neolithic implements were also found. But, more interesting was the chance discovery of a terra-cotta tuyere in the vicinity. It was found along with quantities of iron slag. This further made us to look for evidences for iron smelting in the site. In what appears to be a half disturbed stone circle which had been pillaged, sufficient quantities of potsherds of the megalithic affinity were found. In the area, adjacent to the circle, we found many pieces of tuyere associated with thick urn (**Plate 24**). The urn piece is almost vitrified. The thickness of the sherd at the rim is nearly 3 to 4 cm. The rim is flat but on the outer side the deep finger print

impressions are seen. It appears that the ore was put into earthen containers for smelting. Probably, there were holes at the bottom for removal of the ash and also for blowing the bellows. More quantities of slag were found all along this spot where tuyeres were located (**Plate 25-25A**). The entire area is covered with cinder and at present local people have used this ash as manure, cementing material for the houses and even for road laying (**Plate 26-27**). Though, for its most part, the ash bed is almost removed, the vertical joints in the granitic boulders have preserved the ash column of about half a meter thickness (**Plate 28**). The ash is buff coloured, some are porous and contaminated by mixing with granitic soil. Since most of the joint planes have preserved the relics of ashes, we can easily estimate the accumulation of ash must have been very huge and ash which is the product of iron smelting clearly establishes a smelting site here in Dimaldinne (**Plate 29**). Therefore, it is inferred that Dimaldinne ash mound has nothing to do with gold extraction. However, the mention of the name *Ponnukundram* has a great significance from the point of view of proximity to the gold mines. **(Plate 30)**

8.3.3 Geological evidences

The geological investigation carried out in western part of Hunkund has brought to light the location of a big iron mine (**Plate 31**). These are located 2 km west of Hunkunda where at the western part of the Patna granite within the migmatitic complex, 2 km long 50m wide band of magnetite quartzite associated with graphitic schist occurs as a major enclave. This group of high grade rocks were earlier referred to as " Sakarsnites" (Jayaram, 1925, Ramachandra Rao and Sripadarao, 1934, Rama Rao, 1962). Such patches are distributed in the vicinity of Sakarsna halli, Betarayaswamikonda, between Kamsamudra on the south and Patna on the north. These high grade rocks are now correlated with Sargur group of rocks.

It is evident that for iron smelting both around Patna and Hunkunda iron ore was derived from the magnetite quartzite occurring in this area.

Analysis of iron slag and ash from both Patna and Hunkunda are given below:

Table IV. Semi quantitative spectrochemical analysis of ash samples from Hunkunda and Patna

Sl.No	ABS				
LabNo	388/1				
Sender's No.		HNK1	HNK2	PT3	PT4
Elements:	Cu	30	30	30	30
	Pb	50	10	50	10
	Zn	<300	<300	<300	<300
	Ni	20	15	20	20
	Co	10	10	15	10
	Mo	<10	<10	<10	<10
	Sn	<10	<10	<10	<10
	Zr	700	500	500	500
	Ag	< 1	<1	<1	<1
	Sb	<200	<200	<200	<200
	As	<300	<300	<300	<300
	Bi	<20	<20	<20	<20
	Cr	100	70	100	70
	V	70	50	50	50
	Ga	15	10	15	10
	Be	<5	<5	<5	<5
	Y	15	10	15	10
	La	50	<30	30	<30
	Nb	<30	<30	<30	<30
		MAJOR OXIDES			
SiO_2		50.46	53.45	54.87	54.10
Al_2O_3		15.13	11.55	14.06	8.86
Fe_2O_3		4.29	3.63	4.56	3.11
TiO_2		0.50	0.51	0.61	0.30
CaO		6.70	6.40	3.02	10.61
MgO		1.44	1.35	2.02	1.78
K_2O		3.76	3.60	3.36	3.40
Na_2O		0.90	0.09	0.08	0.08
MnO		0.07	0.09	0.08	0.08
LOI		15.77	15.27	12.54	18.00

All values are in ppm.

Samples analysed at Chemical Laboratory, Airborne Mineral Surveys and Exploration Wing, Geological Survey of India, Bangalore

Table V. Chemical analysis of slag samples from Patna and Hunkund

Oxides	samples PTS1	PTS2	PTS3	HNK1	HNK2	HNK3	HNK4
SiO_2	33.37	15.00	14.29	29.32	33.94	47.94	28.37
Fe_2O_3	49.40	68.20	71.00	60.40	55.00	30.80	61.30
Al_2O_3	7.05	4.46	2.22	4.95	3.95	11.55	4.54
TiO_2	0.42	0.30	0.17	0.26	0.21	0.40	0.26
CaO	5.84	3.73	1.16	4.00	4.95	3.66	2.63
MgO	0.83	0.72	0.48	0.98	0.56	0.09	0.90
Na_2O	0.28	0.10	0.06	0.16	0.11	0.45	0.25
KaO	1.19	0.32	0.25	1.20	0.96	1.85	1.19
MnO	1.45	1.75	1.33	1.52	1.50	1.13	0.90
L.O.I	<0.1	4.17	10.05	<0.1	<0.1	1.10	<0.1

Samples analysed at Chemical Laboratory, AMSE wing, G.S.I., Bangalore by AAS method.

Patna and Hunkund are not stray cases of iron smelting sites in Karnataka. Banahalli (12°58' : 78°06') a village 2 km. from Tekal railway station on Bangalore - Madras broad gauge represents the largest neolithic - megalithic settlement in south India (Krihsnamurthy, 1985). The metallurgical investigations carried out in this site has brought to light a large amount of slag, tuyere etc. indicating that iron was smelted here. This is supported by chemical analysis of slag. Slag is analysed 38.54 % Fe, 1.10% Mn, 33.71% SiO_2, 12.83% Al_2O_3, 11.35% Cao, 0.91% MgO. The high percentage of Cao is attributed to limestone used as flux in iron smelting. (Rao, 1986-87).

8.4 STUDY OF SLAG MATERIAL FROM DIFFERENT GOLD MINING AREAS IN KARNATAKA

With the object of establishing the mining history of ancient gold workings, a careful survey was undertaken around some of the workings. In the process, at a number of sites, slag accumulation was noticed. The concentration of the slag in most of the cases are either right over the ancient workings or nearby the sites. An attempt is made to understand the slag heaps and their relevance to gold mining if any. The sites surveyed are :

1. Cheeranahalli in Hassan district
2. Ettinhatti in Bellary district
3. Chinmalgund in Dharwar district

A brief description of each site and the chemical analysis of the slag is described below:

8.4.1 Cheeranahalli slag samples

Cheeranahalli is a small village (lat. 13°11'40" : long . 76°15'00", covered in toposheet No. 57C/8) in Arasikere taluk, Hassan district and is roughly about 8.5 km. W.N.W. of Gandasi village. Gandasi town is on Mysore - Arasikere state highway and is located 18 km south of Arasikere.

A small slag mound is exposed about 1.5 km southeast of Cheeranahalli. This mound is located on the banded biotite gneiss bordered on the east by talc tremolite schist. There are innumerable broken tuyere and slag pieces shrewn over a large area. These are associated with powdery black ash and charcoal. It is an oval shaped mound stretching 10 m in north west direction with a maximum width of about 5 m in the middle part. Broken crucibles with solidified iron melt sticking to the crucibles were collected from the slag mound by opening a pit of 30 cm. deep. From the surface, ash mound rises to a height of about 50 cm. About 10 m N.N.E. of the mound, a heap of crucible and slag has been dumped which makes a height of about 45 cm. About 7 m west of the dump 2 small pits were dug and fresh charcoal was collected. A careful survey of the entire area did not reveal any nearby source of iron ore and this indicates that the source is from the transported material. The analysis of the slag clearly indicates that the site was an iron smelting one. Major oxides analysed are reproduced below:

Table VI. Chemical analysis of slag samples from Cheeranahalli

Sample Nos / Oxides	SLG	CH-I	CH-2	CH-3	CH-4	CH-5	CH-6
SiO_2	28.46	28.34	16.30	10.97	65.82	66.12	10.98
Fe_2O_3	15.61	51.10	65.31	78.57	7.49	8.40	77.96
Al_2O_3	17.66	7.84	7.00	3.01	16.13	15.79	3.07
CaO	0.52	9.10	9.28	7.08	1.98	2.54	7.06
MgO	27.01	1.51	0.97	1.06	0.85	0.83	1.03
TiO_2	0.69	0.14	0.11	0.00	0.28	0.38	0.00
Na_2O	0.15	1.17	0.46	0.28	3.16	2.92	0.28
K_2O	0.02	0.80	0.50	0.30	1.95	2.23	0.36
MnO	0.06	0.10	0.38	0.05	0.02	0.04	0.05
L.O.I.	10.0	0.00	0.00	0.00	1.50	1.20	0.00
Total	100.20	100.10	100.30	101.30	99.20	100.40	100.80

Samples analysed at Chemical Laboratory, AMSE wing, G.S.I., Bangalore by AAS method.

The chemical analysis indicates a high Fe_2O_3 upto 78.57% for slag while, these spongy slag has analysed upto 51.10%. The slag pieces which are highly smooth and completely vitrified have analysed SiO_2 upto 63.82%. The high CaO percentage (upto 9.28%) clearly indicates that lime stone was used as flux. None of the samples have indicated any gold value. It is obvious that this is an iron smelting site but its importance lies in the fact that this is located very near to ancient gold working.

Half a km east of slag heap, there are a series of shallow gold workings within the talc tremolite schist and the well known Gollaharahalli workings are 2 km south east of the present slag mound. The Vitalapura and Yelwari gold workings are 8 km N.N.W. of this mound.

Gollarahalli ancient workings were first reported by Bruce Foote(1889) who noticed extensive shallow workings and recommended for detailed prospecting. Sampath Iyengar (1919) described a series of old workings within the hornblende schist and reported an oval pit and a number of trenches at the origin of 2 nallas draining into Gollarahalli tank W.N.W. of Gandasi. He attributed quartz dumps to brisk ancient mining activity (Nagaraja Rao *et al.*, 1994).

GEOLOGICAL MAP OF GOLLARAHALLI-YELAVARE AREA, HASSAN DISTRICT KARNATAKA.

(PARTS OF 57C/3,4,7 & 8)

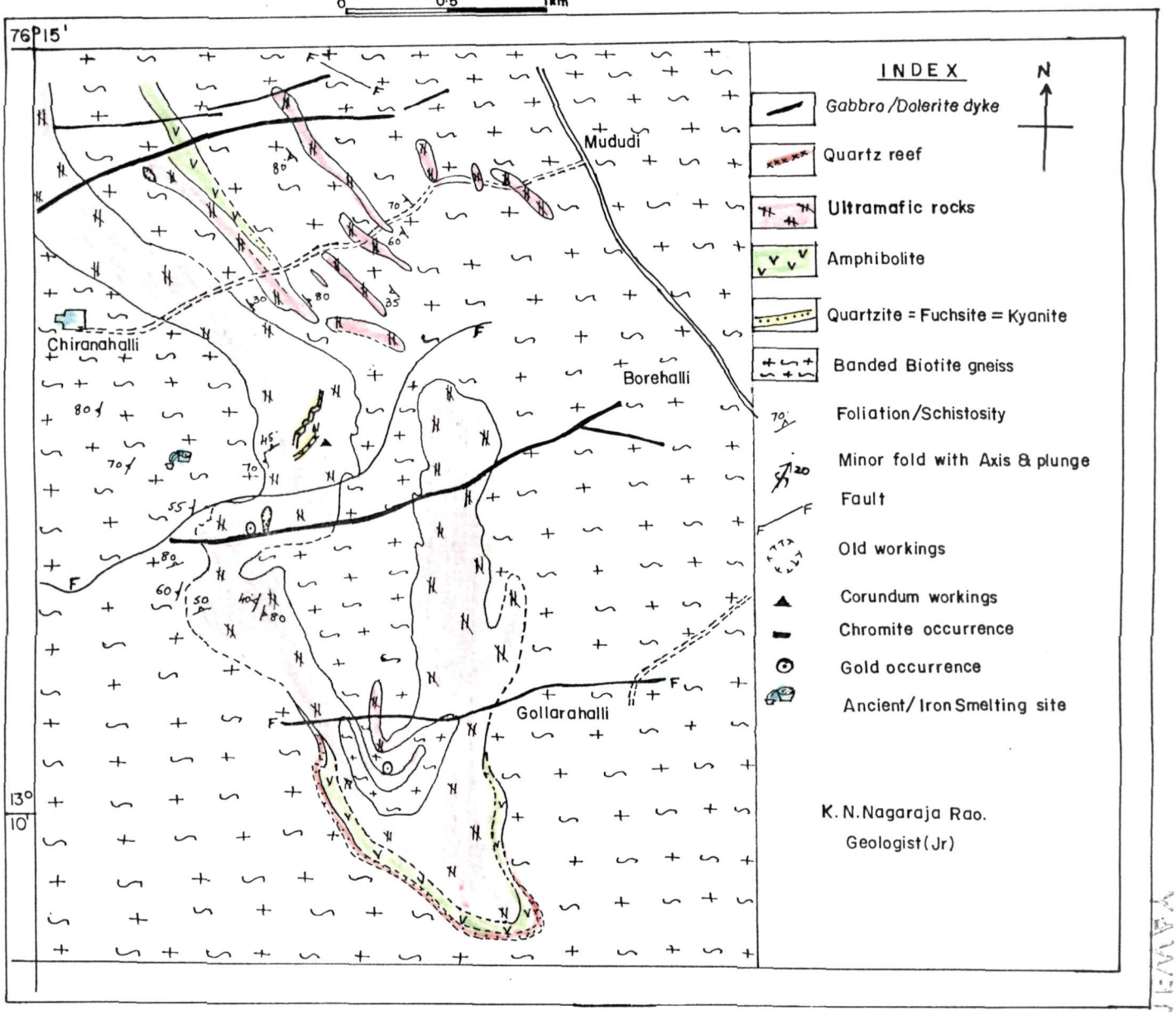


Fig 8·4·1

Gollarahalli schist enclave occurs as a dismembered body within the peninsular gneiss and lies between Nuggihalli schist belt on the east and the eastern arm of fork shaped Holenarsipur schist belt on the west. It is mainly made up of dunite, talc chlorite tremolite schist, metapyroxenite, amphibolite and quartzite invaded by biotite gneiss, garnetiferous biotite gneiss and are classified under Sargur Group (Swami Nath and Ramakrishnan, 1981).

Gold mineralisation is confined to the contact of garnetiferous biotite gneiss with metapyroxenite and is controlled by axial plane cleavage of the synformal fold. The author was associated with the detailed investigation for gold in Gollarahalli area taken up by Geological Survey of India (Nagaraja Rao *et al.*, 1994). Fig.8.4.1.

8.4.2 Ettinahatti slag samples

Ettinahatti is a village in Sandur taluk of Bellary district. It is renamed as Taranagar (lat : 15°08'00" : Long: 76°37'00"). It is situated on the northern side of Sandur, the taluk Headquarters and the Sandur is 11 km from Taranagar on Bellary -Kudligi state highway.

Ettinahatti gold workings were first reported by Robert Seawell in 1893 (Madras Mail of August, 1893) giving the detailed account of 3 drives, which were already existing at the time of his visit. Subsequently, W. Francis (1904) has recorded gold workings (Surang maradi) in Madras District Gazetteer. He further mentions that they were all greatly chocked with mud and debris and is not known whether the mines were abandoned because of the failure of the vain or in consequence of one of the many political convulsions which passed over this country.

This ancient working has been investigated by Geological Survey of India by mapping, trenching and sampling. This area represents massive and

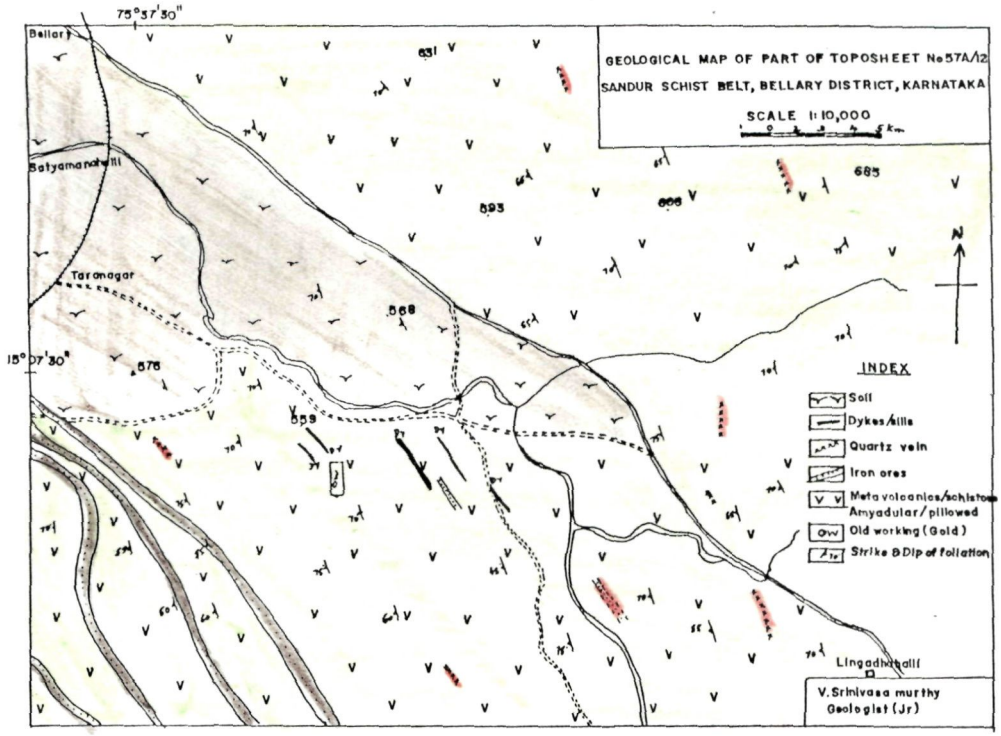

75°37'30"
Bellary
Satyamanahalli
Taranagar
15°07'30"
GEOLOGICAL MAP OF PART OF TOPOSHEET No 57A/12
SANDUR SCHIST BELT, BELLARY DISTRICT, KARNATAKA
SCALE 1:10,000
N
INDEX
Soil
Dykes/Sills
Quartz vein
Iron ores
Meta volcanics/schistose Amygadular/pillowed
Old working (Gold)
Strike & Dip of foliation
Lingadhalli
V. Srinivasa murthy
Geologist (Jr)

Fig-8·4-2

schistose metabasalt associated with iron formation belonging to Nandihalli Formation of Sandur Group of Dharwar Super Group (Fig.8.4.2). The old workings are located at the contact of carbonated massive and schistose metabasalt (Srinivasa Murthy, 1992). Old workings have been reported to have been spread over 300 m and in all there are 3 drives of 22 m., 22.5 m. and 2.4 m. length each. During the investigation, between northern and the middle drive, old fill has been located and the excavation yielded plenty of slag . Analysis indicated high SiO_2 and CaO. Very little doubt exists about the source of this slag. It is evident that iron bands just 200 m distance have served as source for smelting. From the analysis no gold has been reported from this slag. In fact, iron smelting is no new activity in Bellary district, which is endowed with very rich iron ore deposits of the country.

Foote (1895) has recorded, that, iron smelting in Bellary district was done at Kamalapura in Hospet taluk at Kanavehalli in Sandur taluk at Mallapura and Shigegudda in the Kudligi taluk. The rich iron ore from the neighbourhood was smelted locally for making bowl shaped boilers used extensively for boiling the sugarcane juice. The evidences of old iron smelting are not seen now in these places except this slag dump(Krishnamurthy, 1978. Analysis of the slag is reproduced below:

Table VII. Chemical analysis of slag from Ettinahatti

Oxides	percentage
SiO_2	62.46
Al_2O_3	7.14
Fe_2O_3	7.97
TiO_2	0.68
CaO	12.00
Mgo	4.56
Na_2O	0.91
K_2O	2.24
MnO	0.14
L.O.I	1.58

Samples analysed at Chemical Laboratory, AMSE wing, G.S.I., Bangalore by AAS method.

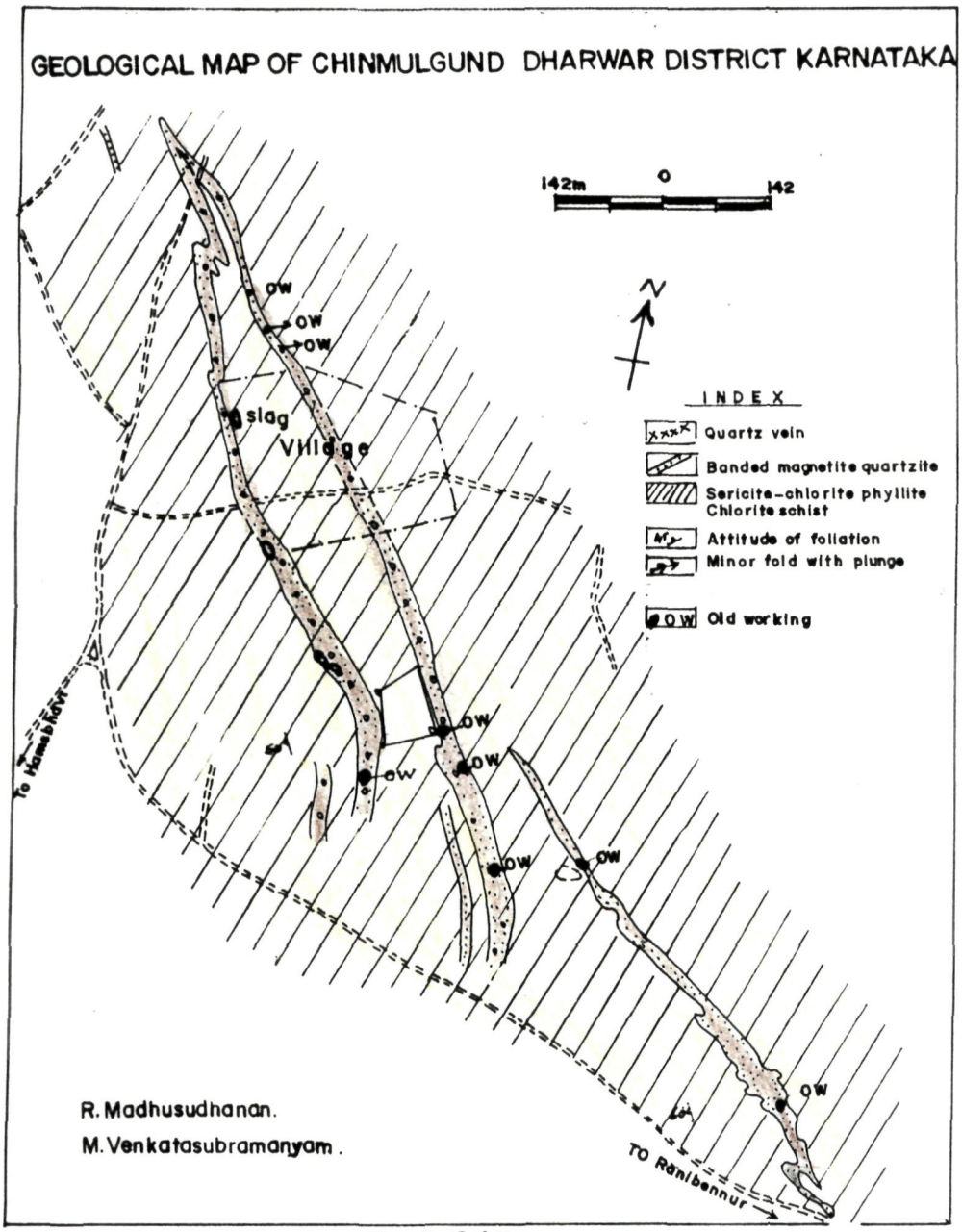

GEOLOGICAL MAP OF CHINMULGUND DHARWAR DISTRICT KARNATAKA
142m
0
142
N
INDEX
Quartz vein
Banded magnetite quartzite
Sericite-chlorite phyllite
Chlorite schist
Attitude of foliation
Minor fold with plunge
OW Old working
OW
Slag
Vhidge
To Hamabikavi
TO Ranibennur
R. Madhusudhanan.
M. Venkatasubramanyam.

Figure - 8·4·3

Therefore, it stands to reason that the slag dump clearly indicates the site of iron smelting and though it is located right over the old working and is not related with gold smelting activity.

8.4.3 Chinmalgund slag samples:

Chinmalgund as the name implies (Chinna= gold in Kannada) has ancient gold workings located about 18 km from Byadagi railway station on Guntakal -Dharwar section of southern railways. Chinmalgund village is located right over the iron formation.

Geological background : Chinmalgund area forms the northern extension of Shimoga schist belt with Precambrian metasedimentary rocks made up of mainly phyllite-chlorite-sericite and banded magnetite quartzite with a number of quartz vein. The banded magnetite quartzite hosts gold mineralisation with sulphide rich altered fractured zones of partings of schist/ tuff containing stringers of quartz forming richer ore shoots. (Fig.8.4.3)

There are a large number of ancient workings in the form of shafts, inclines, pits and openings spread over a distance of nearly 3 km. Some workings have reached a depth of 30-40 m. Primarily, the rich oxide zone has been scooped out by the ancients and are aligned along the footwall contact of banded magnetite quartzite. Recent work by Geological Survey of India has established a good length of auriferous zone and is considered as one of the good deposits hosted in banded magnetite quartzite (Madhusudanan and Venkatasubramanyam, 1993).

On the eastern band of the iron formation near Chinmalgund village, a large number of slag pieces have been shrewn on the cultivated field. This slag for its most part is hard and rarely spongy varieties are met with. The analysis of the slag samples have shown high percentage of Fe_2O_3 upto

67.80% and SiO_2 varies from 20.54% to 35.29% The high percentage of iron in the slag indicates that much of the iron available in the ore was last in the slag and the temperature was sufficient to tap the slag. Interestingly, one of the slag samples has indicated more than 1.5g/t of gold analysing very high arsenic (Personal communication by Raghunandan). This clearly demonstrates that the iron ore available from the in-situ deposit has been made use of for smelting.

Table VIII. The analysis of slag from Chinmalgund

Oxides	Samples CHM1	CHM2	CHM3
SiO_2	35.29	27.54	20.54
Fe_2O_3	53.30	64.90	67.80
Al_2O_3	5.27	5.33	4.56
TiO_2	0.18	0.21	0.18
CaO	3.47	5.28	4.88
MgO	1.12	1.41	1.53
Na_2O	0.72	0.27	0.18
K_2O	0.78	0.46	0.41
MnO	0.09	0.08	0.06
L.O.I.	-	-	-
Au	<10ppb	<10ppb	<10 ppb

Samples analysed at Chemical Laboratory, AMSE wing, G.S.I., Bangalore by AAS method.

8.4.4 The importance of iron smelting

Karnataka is known for rich high grade iron ore deposits. It is no surprise that the ancients have made use of the available iron ore resources for smelting since a very long time. Specially, where rich deposits are available invariably one or two smelting sites have been noticed.

Francis Buchanan (1807) extensively undertook travel through erstwhile Mysore, Canara and Malabar has recorded a number of iron smelting sites which were operating during that period. The list includes smelting centers such as Savanadurga-Ghattipura (Ghatti = ingot in Kannada) from Magadi taluk, Madhugiri, Chennarayadurga, Hagalvadi, Doraigudda and Deverayanadurga from Tumkur district, Mota near Sargur in

Heggadadevanakote taluk, Mysore district, Yelladakeri, Chikbylkere, Bukkasagar in Chitradurga district, Banasandra near Malavalli from Mandya district.

Iron smelting centres which were active in Bellary district have been described by W. Francis and Bruce Foote and this has already been discussed.

The importance of iron tools as mining equipments is known rather too well. It is indispensable for deepening the mine, though fire setting and quenching forms part of the mining operations. Fire setting alone can never be employed as the only technique for mining. Handtools particularly chisel, crowbar, iron pans are indispensable for a large scale mining.

Iron smelting in India has a long history. As noted by Hegde (1991) it is not yet clear where exactly the first deliberate smelting of iron was started. Archaeological records indicates that from 2000 B.C. to 1200 B.C. iron objects in west Asian sites gradually increased. Almost a similar slow development in the production of iron object took place in India (Page 36). By 4th Century, B.C. the knowledge of iron technology has spread all over the country and the industry had reached its mature stage. This is amply reflected in the nationwide occurrence of wide ranging iron weapons and implements recovered in the contemporary archaeological records. Numerous standing monuments of the last quarter of the first millennium B.C., either carried into rocks or built of blocks of stone are a testimony to the excellent quality of ancient Indian iron chisel.

It is no exaggeration that iron implements proved extraordinarily handy for ancient gold mining also. This has been amply demonstrated in the occurrence of iron pans in both Hutti and Kolar gold mines.

In the light of the present study of slag mounds described, around the ancient gold mines, it can be inferred that the iron smelting sites were meant

at least in this part for making implements to help deepening the mines. However, we have to exercise a lot of care as to not to relate all the iron smelting to the manufacture of implements for mining industry, since, many such occurrence are seen outside the gold fields also. The clear markings of crowbar in many of the ancient workings of Bellibetta in K.R.Pet taluk, Madya district stand as testimony for use of iron in the mining industry. Probably, systematic excavations of all the old workings for gold may yield tangible results.

8.5 BELLIBETTA : AN IRON AGE GOLD WORKING IN K.R.PET TALUK, MANDYA DISTRICT

Classification of ancient mines into different periods requires supporting evidences from both the disciplines namely geology and archaeology. At present Carbon datings are available only for Hutti and Kolar Gold mines. For other mines, where it is difficult to obtain material for dating a careful survey of the mines may indicate some evidences which needs a logistic interpretation. Bellibetta gold workings have provided one such evidences to classify them under iron age.

The author has carried out a detailed study of the ancient working involving mapping, deepening of the ancient workings and panning of the samples which has yielded good results by way of recovering gold. The detailed investigations has established the auriferous nature of the rock and is also supported by a number of old workings surrounded by pounding marks due to crushing of the ore.

8.5.1 Geographical location and brief geology

Bellibetta(12°38'15" : 76°27'00") forms the middle part of Krishnaraj Pet schist belt which extends from Mandagere on the north upto K.R.Sagar

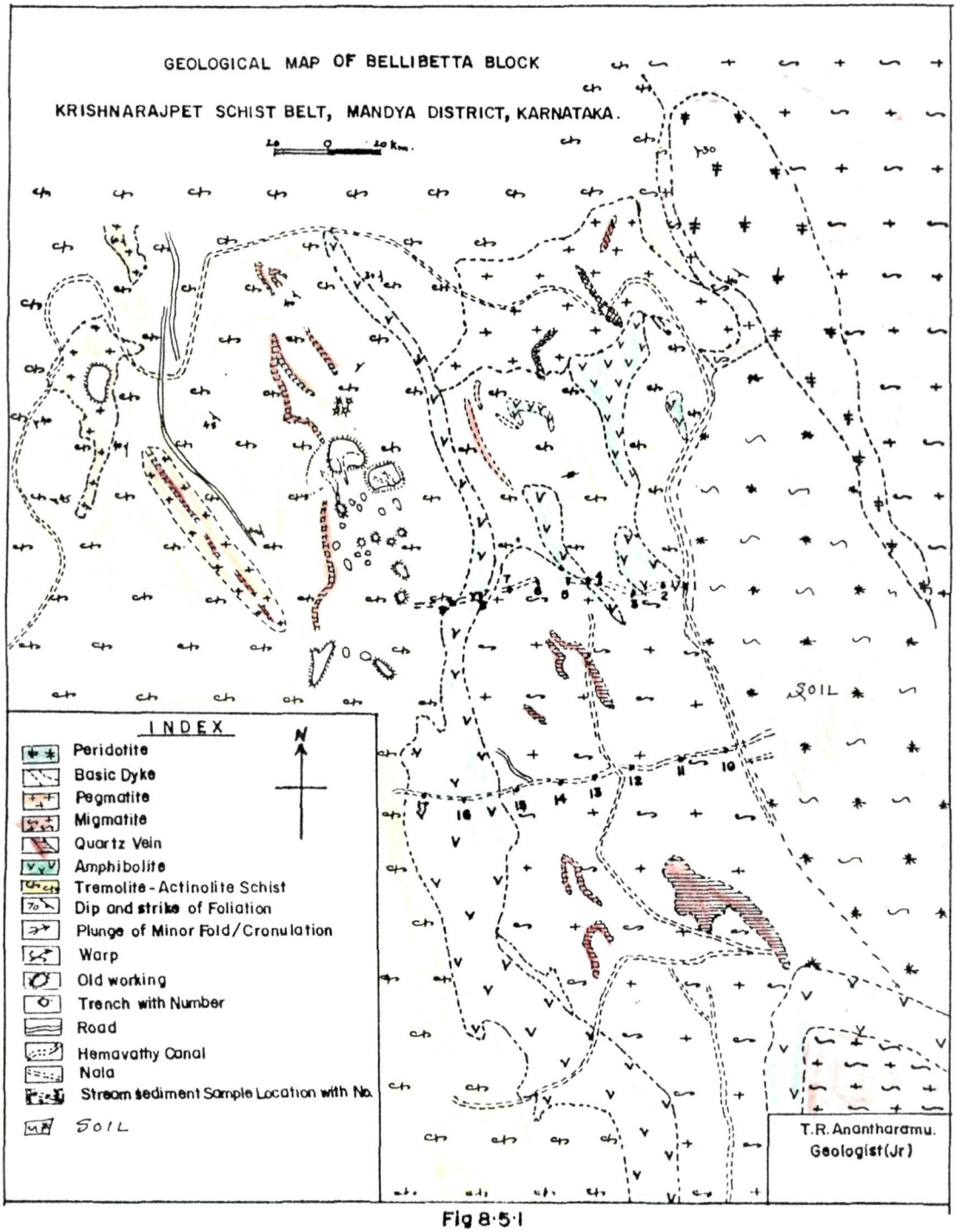

GEOLOGICAL MAP OF BELLIBETTA BLOCK
KRISHNARAJPET SCHIST BELT, MANDYA DISTRICT, KARNATAKA.
20 0 20 km.
INDEX
N
Peridotite
Basic Dyke
Pegmatite
Migmatite
Quartz Vein
Amphibolite
Tremolite - Actinolite Schist
Dip and strike of Foliation
Plunge of Minor Fold/Cronulation
Warp
Old working
Trench with Number
Road
Hemavathy Canal
Nala
Stream sediment Sample Location with No.
SOIL
SOIL
T.R. Anantharamu.
Geologist(Jr)

Fig 8·5·1

dam to the south over a length of 30 km in N.N.W - S.S.E direction. At Bellibetta, the schist belt has a width of about 3 km. K.R.Pet, the taluk headquarters is 5 km east of Bellibetta. This area is covered by parts of Toposheet No. 57D/6, in Mandya district.

K.R.Pet schist belt represents one of the well developed early Archaean green stone belts or ancient supracrustals . Bellibetta exposes a thick pile of mafic-ultramafic sequence represented by actinolite-tremolite±chlorite schist which constitutes about 75% of the lithological unit. This is followed by a subordinate representation of amphibolite and a limited occurrence of quartzite member. The mafic-ultramafic sequence in intruded by peridotite on the eastern margin and by olivine diabase in the middle part. There are both pre and post-tectonic quartz veins and structurally, Bellibetta range represents a major south plunging synform. The entire schist belt is migmatised at the contact (Anantharamu and Devapriyan, 1993) Fig.8.5.1.

8.5.2 The early prospecting

Bellibetta attracted the prospectors as early as 1888, when Bruce Foote gave a detailed account of the nature of ancient gold workings in this part. At the time of his visit, the workings were filled with debris which he thought was intentional. However, he mentions that the name Bellibetta has nothing to do with silver but opines that it would have been the corrupt form of Bilibetta (White hill, since there are numerous quartz vein). The new Kempinkote company worked this property in 1901-02 sinking few shafts but it appears no commercial mineralisation was intersected (**Plate 32**).

8.5.3 Old workings as evidence for iron-age mining

Incidence of gold : In the course of investigation all the old workings of Bellibetta were studied in detail and located on the plane table map on

1:1000 scale. Altogether there are 30 old workings on the northern flank with varying dimension and depth. Most of the workings are shallow, extending just 3-4 m deep and are round to oval in shape. They are mined by sinking shaft and show a maximum diameter of 12 m. The clustering of old workings are seen from .922 peak upto 300 m north. As many as 15 old workings are located in meta ultramafites.

Panning of old fill removed from the working has returned appreciable amount of gold.

Initial weight of the samples treated :	2750 g.
Weight of +10 fineness :	1250 g.
Weight of +18 fineness :	450 g.
Sample treated by panning :	1050 g.

On an average 100 kg. of mine fill on reducing to 2.5 g. concentrate has shown 5 specks of visible gold and the assay value ranges from 1.20 ppb to 55 ppb of gold/tonne.

The result of stream sediment samples is indicated below

Stream-1	4-18 gold specks	2.55 ppb/20 kg material
Stream-2	3-10 gold specks	3.50-5.50 ppb/20kg
Stream-3	3-4 gold specks	7.20-55 ppb/20 kg
Stream-4	3 gold specks	17.60 ppb/20 kg.

There is no doubt that the ancients have worked for gold by digging shallow pits. Since there is no sulphide association, it was rather easy to crush the samples and recover gold. It is a free milling type.

Method of Mining : As already discussed, most of the old workings are shallow and are located on talc tremolite schist intruded by quartz vein. Except the shaft opened by the earlier mining company, which at present is

not accessible owing to huge mining debris, the other openings are quite accessible. While deepening the walls of all the old workings, it was carefully observed that none of the workings carry any traces of fire setting. It is no surprise, for, these rocks are soft and can quickly be worked with ease. This is borne out by the fact that in almost all the workings, there are clear marks of grooves evidently left by the implements used for deepening. Such markings are well preserved in one of the old workings numbered as OW 27 which was bottomed at 5.50 m. depth. The markings are related to crowbar and are preserved upto 3.80 m depth. By the surface study, it is evident that these markings are the impressions of the crowbar. Some are about 7 cm. long and half a cm. wide and persist upto 0.5 cm depth on the wall (**Plate 33**). The second important observation made is the steps made by the ancient miners to lift the material which were mined. These are semi circular in shape and have a width of nearly 55 cm. and are carved regularly at every 1.5 m depth.

Pounding marks : Pounding marks are invariably seen clustering around the old workings right over the in-situ rocks (actinolite-tremolite schist). The diameter of the pounding marks vary from 14-25 cm. and depth 6-7.5cm. This clearly demonstrates that the ore removed from the mines was crushed right over the mine head. Since, gold is free milling type (not associated with any sulphides) perhaps the simple operation of crushing would have been sufficient to win the metal. (**Plate 34-36**)

At the foothill, 2 more pounding marks were seen in the dolerite with diameter upto 16 cm (**Plate 37**). The samples crushed are treated by water for gravity separation. Panning was the best method employed by the ancients to recover the gold. There are as many as 98 pounding marks preserved on the gneissic outcrop, about 500 m. northeast of Bellibetta range, where a

stream drains the area (**Plate 38-39**). Since water was available in plenty by nearby source, the bed rock immediately adjoining the nalla has been made use of for pounding. On an average 6 pounding marks are observed over a sq. m. area. The pounding marks occupy a total of 7 X 14.50 m. area. Here, the diameter of the pounding marks vary from 13 - 20 cm. and the depth 2.50 - 7.50 cm. Since there are as many as 30 old workings, the material mined must have been quite huge and proportionately there are as many as 98 pounding marks for crushing the ore. This is the highest concentration of pounding marks recorded by the author in the area surveyed.

Chapter 9

RADIOCARBON DATES OF GOLD MINES OF KARNATAKA

Radio carbon dates available for gold mines of Karnataka are very few. There are inherent problems in getting the material for dating. In the first place, only the deep gold mines which needed pillaring for support offer some scope for recovering wood or other material for dating. Secondly, since many ancient workings have not been systematically excavated by removing the debris, the chances of recovering charcoal is rather very limited. Though, fire setting and quenching was a common practice of mining, rarely we get any charcoal. Where only shallow ancient workings exist, as is the case in most auriferous tracts of Karnataka, there is total absence of material needed for dating. The other important disadvantage for dating the gold mine is the rarity of crucible and associated charcoal. On the contrary, we get enough pestle, mortar and pounding marks from almost all the gold working sites as a testimony for crushing of gold ore. Hence, dating of gold mines poses a great problem. Nevertheless, we have carbon dates from Kolar, Hutti and Chigargunta workings. The last mentioned working is situated on the southern extension of Kolar gold Field.

The radio carbon dates are reproduced below:

Table IX. ^{14}C Dates of Gold Workings

Site	Sample	Location	^{14}C dates in B.P. (based on 5730 years)
1 Kolar	TF 1199	Superficial excavations	1290±90
2.Kolar	TF 879	Champion reef 50 m depth	1500±115
3 Hutti	S.No.1	Oakleys's shaft 80 m depth	1945±70
4 Hutti	S.No.2	"	1865±70
5.Chigargunta	charcoal	-	1270±120
6.Chigargunta	charcoal	-	1050±120

Source : 1. D.P. Agarwal and C. Margabandhu. *Puratattva*. Bull. Arch. Soci. No.8, 1975-76, p.139 2. D.P.Agarwal, S. Kusumagar and M.G. Yadava. Phys. Resc. Lab. Radio carbon date list. vi. Radiocarbon, v.37, No.3, 1991. pp. 329-344.

9.1 INTERPRETATION OF RESULTS

The radio carbon dates from Kolar Gold Mines indicate that, during 5th and 7th Century A.D. these mines were active. The Chigargunta mines located on the southern tip of Kolar Gold Fields almost confirms the same dates but were active in the 10th century and 13th century A.D. Hutti gold mines as indicated by Carbon dates were active in the early Christian era. We have to bear in mind that these dates indicate only the progress achieved during those period, but, may not indicate the date of initiation of the mines. This is supported by the fact that in Hutti gold mines, the logs used for supporting the mine were recovered from a depth of 80 m. in Oakley's shaft. Similarly, from Kolar gold mines, the samples for Carbon dating came from a depth of 50 m. Therefore, it is obvious that the early mining activity is much more earlier than the radio carbon dates suggest. (**Plate 40**)

These dates are further confirmed by archaeological objects recovered from the mines. Specially, the objects from Hutti mines include coarse, pink, red earthware, cylindrical grinding stone of pink porphyritic granite, small stone discs of chlorite schist, spheroid, circular beads of conch shells which range in age from 1st Century B.C. to 3rd Century A.D. (Allchin, 1962). These findings are now preserved in the geological museum of Hutti, which, in addition to all these objects mentioned above, also contains a small crucible recovered from Wandalli area suggestive of gold smelting on a smaller scale. (**Plate 41-42**)

The recent excavations carried out by Geological Survey of India in Chikkhesarur area about 5 km. west of Pamanakallu and about 12 km. S.S.W. of Hutti main mine, an iron pestle which was used for pounding the gold ore has been recovered from one of the ancient workings (**Plate 43**). It is a pestle made up of cast iron 20 cm long weighing 2.250 kg. The blunt end of the pestle is bulbous having a circumference of 23 cm and the handle

measures 70 cm long. (Personal communication from Shashimohan, Geologist, Geological Survey of India).This clearly bears testimony to the continued gold mining activity in the iron age perhaps may belong to historic times.

9.1.1 Gap in the record of gold mining activity

Radio carbon dates available for both Kolar and Hutti mines however, point to the mining activity which was continued during the first century A.D. and subsequently in 5th and 7th Century A.D. This certainly gives a doubt as to whether gold mining was suspended for centuries. In other words, whether mining activity was intermittent ? Many geologists have pondered over this and have tried to analyse this problem from the historic point of view. Munn(1934) strongly feels that by the time of Mohammadan conquest, it seems certain that gold mining in the Deccan had long been forgotten and the idea that it existed in the time of Vijayanagar is unfeasible; else, it could have surely been mentioned by Portugese visitors to that court, since, there were Portugese Christian missionaries at Mudgal.

Visitors to the great Vijayanagar kingdom, namely Caeser Frederick(1567 A.D.) Domingo Paes (1520-22) Fernao Nuniz (1535-37) Abdul Razak (1442 A.D.) Duarte Barbuza (1503), Nicolo Di Conti (1420), Linscothen (1594) have described in great detail the fabulous wealth of the kingdom. The description includes the famous diamond localities of eastern Krishna region which covers the well known Golkonda mines. It is surprising that Hutti gold mines which were within the reach of the empire have escaped the attention of the travellers. It is even more surprising that the different kingdoms in the south have enjoyed the gold currency for centuries, yet, there is no mention of the source of gold for their mints. To clinch this issue, it needs a clear understanding of the trade and commerce and various revenue sources available in each period.

9.1.2 Gold mining in Tippu Sultan's regime

In Tippu's regime itself, we come across with different mints established in the entire south India. But, all of them were not equally active and all the mints did not strike coins in all the three metals namely gold, silver and copper. However, the historians feel that the places for mints were carefully selected based on military and political importance (Narasimha Murthy, 1989). For instance, in Srirangapatna, the headquarters of Tippu Sultan, there were five mints striking gold, copper and silver coins.

Tippu's letter of 19th November, 1786 and 20th December, 1786 mentions that, there were in the treasury several lakhs of pagodas weight of gold and silver appropriated to the coinage of pagodas etc. In the capital itself, there was more than one mint. One of Tippu's commercial regulations states that the Board of Trade officers were to collect all the gold from various factories under their directions and to send the same to be coined in the 4th mint at Srirangapatna. There were on the whole, 5 mints in the Capital (Gopal, 1971).

If we considered the locations of these mints, it may not be surprising that some mints are at least nearer to the gold fields, for instance, the Dharwar mint, where all the 3 metal coins were struck is not far from the famous Gadag Gold Field. Similarly, at Gooty, there was one more mint, however, though Gooty is known for gold mine, gold coins were not struck in this mint. But, we have to exercise precaution before drawing conclusions and there is no correlation between the location of the mints and the gold mines. Nevertheless, the records of Lt. Warren (Heathcote, 1927) clearly mentions that Tippu had sent a Brahmin to examine the reopening of ancient mine of Marikuppam in Kolar gold field. The report says that after a trial of several weeks, that the produce just balanced the expenses incurred and left no profit

to the Circar (Government) and the attempt was dropped. It is to be noted that these gold mines were under the scrutiny of Tippu Sultan.

Ramgiri gold field located on the south western part of Dharmawaram taluk in Ananthpur district, has numerous ancient workings for gold in the form of long, narrow trenches scattered over 12 km near Ramgiri village. These workings are reported to belong to the period of Tippu Sultan (Krishnamurthy, 1963).

At Hadabanahatta, about 3 km north of P.G. Palya in Kollegal taluk, Mysore district, extensive old workings for gold have been recorded. The workings have reached upto 6 to 8 m depth and examination by Geological Survey of India has indicated that in this place, gold is associated with the sulphides. This gold mine is said to have been worked during Hyder Ali and Tippu Sultan and were abandoned after the invasion by the British (Ziauddin and Narayanaswamy, 1974).

9.2 A COMPARATIVE STUDY OF MINING ARCHAEOLOGY OF METALLIFEROUS MINES OF INDIA

Though India can boast a good number of base metal and gold mines, mining archaeology has not made much advance. The radio carbon datings in the early eighties have been carried out for Hutti and Kolar gold mines. In this chapter, an attempt has been made to compare the data available for different metalliferous mines of the country so that the contemporary developments in the mining can be better understood.

At present, radio carbon dates are available for lead, zinc and copper mines of Aravali in Rajastan, few copper mines of Gujarat and Andhra Pradesh and copper mines of Ingaldal, Karnataka. Agarwal *et al.*, (1976) have dated a number of sample from these copper mines. In addition, collaborative

mining archaeological work taken carried by Hindustan Zincs Ltd. with M.S.University, Baroda with the research laboratory of British Museum has brought out significant carbon dates specially for lead and zinc mines of Rajasthan.

9.2.1. Radio carbon dating for some basemetal mines of Aravali range

Aravali ranges of Rajasthan in northwestern part of India, exposes precambrian metasedimentary rocks which have hosted rich deposits of copper, lead and zinc. The northeastern part of the Aravali range is rich in copper and poorer in zinc and lead deposits. While, the central and south western parts are rich in lead and are but poorer in copper. The detailed mining archaeological investigation carried out in Aravali range for copper mines have indicated deep ancient workings with a lot of copper smelting furnace with tuyere.

Aravali copper deposits seem to have been worked during the post Harappan chalcolithic period. Copper and bronze artifacts in the Indian subcontinent dates from the early centuries of 3rd millennium B.C. They are recovered from pre-Harappan peasant settlements in Baluchisthan, Indus valley and Rajasthan. From this date, copper and bronze continued as dominant material for tool production in India until the emergence of iron in the early centuries of the 1st millennium B.C. Thus, the copper and bronze age in India spanned over 2000 years(Hegde, 1991) In fact, it is Rajpur Dariba copper mines in India which have returned the earliest mining dates. We have two Radio Carbon dates available for this mine.

1. 3120 ± 160 years B.P. (H.Z.L., 1980) and

2. 2310 ± 105 years B.P. (Agarwal, 1976) (Source: Hegde, 1991)

The second date is from sample drawn from 64 m depth, while the first one is from timber support recovered from the gallary at 120 m. (Hegde, 1991). Hegde opines that superficial shallow gouging pits are the earliest attempt of mining copper in the Aravali hills. Deep shafts complete with gallaries, steps and ventilation may represent later mining activity and some of the deep mines were worked during the chalcolithic period.

Lead and zinc mines of Zawar in the same precambrian set up of Aravali range in Rajasthan are well investigated from the point of view of mining archaeology and quite a number of copper mining dates are available for these mines. The Zawar mala which is practically dotted with ancient lead and zinc mines is located 38 km. south of Udaipur (Lat.24°21': Long.73°41'). The precambrian metasedimentary rocks are represented by phyllite, quartzite and dolomite. The argentiferous zinc-lead ore is hosted in dolomite.

In the Zawar mala mines, the ancients have followed steeply dipping ore bodies over a depth of 100-150 m. the excavations have brought to light many shafts opened into gallaries and narrow tunnels following the natural configuration of veins at different levels. The most astonishing thing is the presence of ventilation shafts of 1.5 - 2.00 m. diameter at regular intervals (Hegde, 1991, p.63). Evidences for fire setting are seen upto 110 m. in the modern mines (Lynn Willeys, 1989).

Among the major objects recovered from the deep mines are the mining tools, like iron chisels, pestle shaped hammer and pear shaped pots for carrying potable water into the mine. The pot is dated into the last part of the 1st millennium B.C. In many of the old workings, wooden ladders, scaffolds and landers which were used to drain water have been recorded.

The amount of mined material near the ancient workings is estimated to be around 600,000 tons (Craddock *et al*, 1989).

Table X. Selected radio carbon dates for Lead-zinc and silver mines of Rajastan

Mine	Material	Ref.	Date (B.P. yr)
Sample from scaffold	wood	BM 2148R	2350 ± 120
Launder, Zawar	Charcoal	PRL 932	2410 ± 100
Zawar lead smelting	Charcoal	BM 2487	1930 ± 80
slag heaps	Charcoal	BM 2484	100 ± 45
Zawar zinc smelting	Charcoal	PRL 935	840 ± 170
retor dumps	Charcoal	BM 2222R	240 ± 110
Agucha cupel debris	Charcoal	BM 2489	2350 ± 40
Dariba mines			
at 64 m depth	Timber	TF 1117	2245 ± 100
Dariba mines			
at 100 m depth	Timber	NPL 270	3040 ± 150
Dariba silver/			
lead slag heap	Charcoal	BM 2490	2340 ± 40

(Craddock et al, 1986)

Explanation

B.S	Birbal Sahni Institute of Palaeobotany, Lucknow
PRL	Physical research Laboratory, Ahmedabad
TF	Tata Institute of Fundamental Research, Bombay
NPL	National Physical Laboratory, Ahmedabad
BM	British Museum

From the available radio carbon dates, it is evident that the Zawar mines were worked during 2410 ± 100 B.P. (Charcoal from launder, Zawar mines) and the earliest lead smelting activity is dated to be 1950 ± 60 B.P. and zinc smelting dates back to 840 ± 170 B.P. (charcoal sample). The lead and silver mines of Dariba(80 km from Udaipur) have given 3040 ± 150 B.P. (timber).

Summing the available radio carbon dates, Craddock *et al*, have opined that the Zawar mala base metal mines were worked predominantly more than 2000 years ago and approximately correspond with the Mauryan empire. But, the zinc smelting belongs to the historical period (14th Century).

9.2.2 Radio carbon dates for Copper mines of Singhbum, Bihar

Next to Khetri copper belt of Rajasthan, it is the Singbhum copper belt of Bihar which has the high potential for copper ore. Singbhum copper belt

stretches over a length of 120 km between Duarapura (lat :22°46': 85°34') in the west and Bahragora (lat 22°16' : 86°43') in the south east.

The ancient metallurgical activity in Singhbhum belt is very vast and bear testimony to an once flourishing copper industry in the area. Stone implements recovered near Talsa(in the vicinity of Turamdih) points to the antiquity of ancient workings. The widely scattered slag heaps, carefully worked out steps and ancient mine dumps indicate the skill and efficiency of miners who worked 2000 years ago. Also the names of the ancients part of Tamluk (Tamralipa) and several place names like Tamapahar, Tamajuri, Tamar, Tamadundri, etc. indicate that the local people were aware of the occurrence of copper ore in the area (Raghunandan *et al.*, 1991).

If we trace back the usage of the word *Tamra*, it is apparent that Rig-veda never mentions this metal. On the contrary, the Rig-vedic people had acquainted with gold and iron. But, *Shukla Yajurveda* which is later to *Rig-veda* mentions copper not as tamra but as loha. *Atharvaveda*(About 1000 B.C) also mentions the red metal copper.

The word *Tamra* for copper appears to have been current in the 3rd century B.C. as it occurs in the ancient medical treatise of Charaka, Shushruta samhita and Kautiliya Arthasastra (Panchanana Niyogi, 1979).

Since, Singhbhum copper belt is having many places names after copper, where old workings for copper exist, it is surmised that the mines must have been active in the 3rd Century B.C. Added, Pataliputra being the headquarters of Mauryan kingdom, these places would not have escaped the attention of the sensitive miners of Mauryan kingdom.

From the carbon dates available the lead and zinc mines of Aravali may score over Kolar and Hutti gold mines in terms of antiquity. However, both

basemetal and gold mining activity points to Mauryan period. There is a large time gap in the mining activity of Zinc in Zawar. There is no evidence of zinc smelting from Christian era upto 14th Century A.D. when large scale zinc smelting was started in Zawar. In gold mining also, similar gaps have been noticed. For instance, we have no records of Hutti gold mining activity after the 2nd century A.D. similarly, after the 7th Century A.D we are not sure who continued mining activity in Kolar gold fields. Whether the mines were closed intentionally due to invasion of Mohammadans is a matter of conjecture. The radio carbon dates from both lead zinc mines of Aravali and mines from Karnataka may point only to the continuity of gold mining activity during the period indicated.

9.2.3 Radio carbon dates for copper mines of Karnataka

Karnataka has three important copper mines, Ingaldal of Chitradurga, Kalyadi of Hassan and Tintini of Gulbarga districts. Of these the Ingaldal copper mines are well documented and many megalithic sites have been described around this area.

Ingaldal mines are located 6 km south east of Chitradurga town. Here, Chitradurga volcanics have hosted chalcopyrite, pyrite and other sulphides. The mining archaeology of Ingaldal is well documented by Shankar (1986). Two samples of wood recovered from 47 m. depth from old workings have indicated 1820 ± 100 B.P. and 2070 ± 110 B.P. These dates push the Ingaldal mines back to 2000 years which falls into the Shatavahana regime and is contemporaneous with gold mining of Hutti.

Table XI. 14^C dates of wooden logs from Ingaldal mines

Sample	Reference	Date (B.P. Yrs.)
Ingwood1	BS 665	1830 ± 100 B.P.
Ingwood2	PRL 1097	2070 ± 110 B.P.

(Shankar, 1986)

Explanation

BS : Birbal Sahni Institute Palaeobotany, Lucknow

PRL : Physical Research Laboratory, Ahamadabad

Chapter 10

SUMMARY AND CONCLUSION

10.1 SUMMARY

The Karnataka craton is one of the classical Precambrian shield areas of the world and has hosted a wide range of both metallic and nonmetallic minerals. Greenstone belts of this craton are literally dotted with gold occurrences, of which Kolar and Hutti belts have a long mining history.

Systematic survey of the ancient workings for gold has brought to light more than 57 locations with numerous ancient workings distributed throughout the craton on in different geological setup comprising right from greenstone belts to the granulite terrain.

In the Hutti gold mines, ancient workings have reached a depth of 195 m. and have the distinction of being the deepest ancient workings in the world. Practically all the payable lodes of the Kolar gold field and other auriferous tracts of Karnataka have been systematically combed by the early miners. Banded iron formations hosted gold have not escaped the trained eyes of the ancients. The relics of such a great feat are seen today as pits, burrows, inclines, dumps, irregular adits etc. and largely serve as guidelines for modern gold prospecting.

The available data on mining archaeology in the country is meager. While, base metal mines of Aravali range in the Indian subcontinent have attracted the archaeometallurgists much earlier, the evaluation of gold mining in terms of antiquity with an integrated approach both geological and archaeological, has made a beginning only in the later part of this century.

Though limited in number, the radio carbon dates push the early gold mining activity in Karnataka to the 1st Century A.D. with a lot of time gap for the subsequent mining activity. The 'hoary past' needs explanation in terms of historical time scale.

In this thesis, an attempt has been made to tie up geological data available for different gold mines, with archaeological information, taking into consideration the early human settlements in and around gold bearing areas. The importance of the neolithic settlements and megaliths of iron age is discussed from the archaeological point and inscription and literary references are drawn to supplement that gold mining activity in Karnataka is by no means a new industry.

10.1 In the **First introductory chapter** the importance of gold and its different natural alloys as well as its abundance in the upper lithosphere is discussed. The lure of gold from historic perspective is reviewed, which includes an account of search for this metal in different parts of the world and specially in the southern part of the Indian Peninsula. In the light of this, the aim and scope of the work and the method followed in pursuing the problem of deciphering the antiquity of gold mines has been defined.

10.1.2 In the **Second chapter** geological setup and gold mineralisation in Karnataka has been dealt, with due emphasis on the primary gold deposits. The chapter also records different geological milieu, specially, gold mineralisation connected with greenstone belts, and the structural control. Thrust is given to the genetic classification of gold deposits with different examples.

10.1.3 In the **Third chapter** a detailed account of the ancient gold workings is presented. It forms the basis for deciphering the early history of gold mining. This takes note of the early surveys carried out in the auriferous tracts of Karnataka and amply demonstrates the importance of ancient workings as guide to modern gold prospecting. The observations made by the earlier workers is recorded here. Ancient workings distributed in different parts of the state have been systematically documented providing

additional information on the present status. The well known Kolar and Hutti gold fields have been discussed taking into stock the historical aspects vis-a-vis geological background.

10.1.4 The **Fourth chapter** comprises data on placer gold occurrences in Karnataka with a brief background on the origin of placer gold. The modern panning activity of gold is reviewed in this chapter. In addition, the methods followed for winning the yellow metal in the earlier days is recorded. This chapter also gives due emphasis on the early literary works particularly of the 12th century A.D., which carry numerous references for gold panning in Karnataka. The place names connected with gold occurrences have merited special mention in this chapter.

10.1.5 In the **Fifth chapter** ancient mining techniques and metallurgy of gold are dealt in detail. Evidences are largely drawn from Hutti and Kolar gold fields whose early history of mining is fairly clear. In order to understand the methods followed by our ancients, various analogies have been cited both from the mining areas of the Indian subcontinent and the European countries. This chapter highlights the magnitude of ancient mining, evidences of mining by fire setting, pounding and crushing of ore in various auriferous tracts. A brief review of the method of mining is also discussed here. While discussing the metallurgical aspects of gold, a historical review finds a place which underlines the importance of pyrometallurgy for base metals and simple crushing and panning for winning gold.

10.1.6 Ash mounds clustering around many ancient gold mines in Karnataka have attracted the attention of geologists and archaeologists alike, since the early part of this century. In the **Sixth chapter**, the relevance of ash mounds to the prehistoric culture has been viewed from various angles. The early interpretations regarding the origin of ash mounds have been

carefully analysed and evaluated by chemical analysis of the ash samples drawn particularly from the Hutti gold fields. A comparative account of the ash analysis with a view to establish their origin, independent of gold mining activity is attempted here. The chapter also takes note of the historical account of use of mercury for amalgamation.

10.1.7 The **Seventh chapter** discusses in detail the neolithic settlements around Raichur gold field, and documents the prehistoric sites which have direct bearing on the initiation of search for yellow metal. The chapter also records the earliest gold objects recovered from the neolithic sites.

10.1.8. The megalithic culture which occurred at the end of chalcolithic culture and ushered in Deccan at about 800 to 700 B.C. had a major impact on mining. All the more, iron tools and implements were widely employed in metalliferous mining. In the **Eighth chapter**, dealing with megalithic culture and its importance in mining, an approach is made to understand the iron age culture and gold mining based on archaeological findings.

Archaeologists have always pleaded that the mines from Karnataka supplied gold to Indus valley civilization. Historians have held Karnataka in great esteem as province of gold in the earlier days too and is reflected in the works of Herodotos, Pliny etc. A brief review has been made here to elucidate maritime connection with the overseas countries. However, note has been made to apply archaeometallurgical methods including trace element analysis of gold artifacts before concluding the identification of possible source of gold. This chapter also glances the early vedic source of gold. The location of rock edicts of Asoka has been described in detail in the light of their distribution over known gold bearing areas. In addition, it considers the influence of ancient gold mining of Karnataka on South African

mining. The data is supplemented by the geological observations made in both the countries.

Inscriptions and early writing have recorded Hunkund near Kolar gold field as the place where gold was extracted in the earlier days. The critical evaluation of this site has been made with new findings of neolithic settlements followed by iron smelting activities in this part. The archaeological findings are also supplemented by the field work resulting in finding out evidences for iron smelting, and locating the iron ore mines nearby this site. This chapter also discusses in detail both the geological and archaeological importance of the place and eliminates the possibilities of gold extraction in this place.

The iron slag occurring around most of the gold mining areas have a special reference in the discussion. The evaluation of such occurrences and their possible role in the manufacture of mining tools are discussed. An iron age gold mine located in Mandya district has been discussed in detail with the geological background outlining the investigations carried out with evidences of use of iron tools for mining.

10.1.9 The **Ninth chapter** ties up the radio carbon dates available for gold mining with the archaeological evidences, to precisely understand the mining history of gold in this part of the subcontinent. The reasons for gap in the mining activity are discussed from the historical point of view. In the second part of the chapter a comparative study of mining archaeology of metalliferous mines of India has been attempted. This exercise underlines the importance of early mining activity of the gold. The zinc and copper mines of Aravali range, copper mines of Singhbhum in Bihar and Karnataka have been discussed in the light of the radio carbon dates available to establish the parallel developments in the mining history.

10.1.10 **Chapter ten** summarises the results of the works carried out by consolidating the overall observations and discussions made in the thesis to trace the early gold mining history. The neolithic settlements in Raichur Doab, the influence of iron age on mining have a great significance in the development of mining, perhaps initiated in the later neolithic period and intensified during Mauryan period, as supported by the records available.

10.1.11 In the light of the present intensification of exploration for gold in Karnataka craton, it is expected that many evidences specially which are helpful for dating are likely to surface out. Such data will be utilised by the author for further filling the minor gaps in the history of gold mining in Karnataka.

10.2 CONCLUSION

Based on the investigation carried out to decipher the antiquity of gold mining in Karnataka, it is possible to arrive at the following conclusion.

10.2.1. In Karnataka craton, greenstone belts have hosted gold mineralisation under varied geological setup. The ancients have systematically combed the entire auriferous tracts leaving ancient workings as testimony to the large scale gold prospecting. This is amply demonstrated in all the schist belts where modern prospectors have stepped in.

10.2.2 Karnataka is the only state contributing to the gold reserves of the country barring a limited production from Andhra Pradesh and both the gold mines, Hutti and Kolar owe their success to the development of ancient workings under modern technology in the later part of the 19th century.

10.2.3 The early surveys carried out in Karnataka soon after the Fourth Mysore war, brought a cluster of ancient workings both around Kolar and

Hutti area indicating that gold mining in Karnataka is by no means a new industry.

10.2.4 Systematic documentation of all the data available for ancient working has brought to light more than 57 locations in Karnataka with numerous ancient and old workings scattered in different geological setup, right from eastern greenstone belt to mobile belt.

10.2.5 Kolar gold field which is one of the chief gold producers of the country with a recorded production of 750 tonnes of gold upto 1990, has about 26 lodes of economic significance. All the lodes have been thoroughly scanned by the ancients over the entire strike length of about 8 km. Before the European prospectors ushered in this field, there already existed ancient workings which had reached more than 100m. depth.

10.2.6 Hutti gold mines in Raichur district have the distinction of being the deepest known ancient workings in the world. Before Hyderabad Deccan company opened the mine in the early part of 20th century, one of the mines from this field had already reached upto 195 m. depth.

10.2.7. Placer gold mining has a long history in Karnataka. Alluvial placers has been worked as early as 12th century A.D. and it is clear from the inscriptions which throws light on placer gold mining from Gadag area. Literary evidences also support this observation as seen from the works of many *vachanakaras* of 12th century A.D.

10.2.8 Many place names connected with gold in Karnataka, virtually are known for gold occurrences. This is also true for many areas outside Karnataka and more particularly Rajastan and Bihar states.

10.2.9 Fire setting and quenching were the chief methods employed by the miners to open the mineralised rocks. Evidences still exist both in Kolar and Hutti mines where fire setting was practiced. The problem of water was

solved by the ancients by dewatering the mine either by using earthen pots or iron pans.

It was easy to separate gold by crushing and pounding the ore and a large number of crushing stone and pounding marks are invariably seen scattered around many of the ancient workings.

Unlike the basemetal extraction which demanded pyrometallurgy winning of gold was almost simple and consequently in Karnataka and elsewhere we do not get either slag or ash as a resultant product.

10.2.10 Ash mounds have no direct relationship with gold metallurgy. They owe their existence to the early neolithic cowdung burning as seen around Wandalli and Gaudur. Some ash mounds are related to iron smelting as recorded from Hunkund, Patna in Kolar district.

10.2.11 The use of mercury was known to Indians prior to Christian era. Kautilya's Arthasastra mentions mercury as *rasa* and mercury could have been used for amalgamation prior to 3rd century B.C. This is supported by the reported recovery of mercury from the crushed crucible near Wandalli from Hutti area.

10.2.12 Neolithic settlement in Raichur Doab has a great significant from the point of view of early gold mining activity. Such settlements clustering around Maski, Piklihal, Lingasgur, Anandgal, Kotegal assume greater importance since they are in the auriferous track. Neolithic period in Deccan commences at the end of third millennium B.C. and extends to the first half of the 1st millennium B.C. This period would have prompted the neolithic people to work the visible gold by making use of the stone implements.

10.2.13 With the introduction of megalithic period or iron age in Deccan, new iron tools were employed for deepening the mines. By the time Mauryan expands their kingdom there existed ancient workings and is rightly hinted

by Kautilya as to how to identify such workings. Therefore, it stands to reason that mining was already a skilled profession prior to Mauryan period.

10.2.14 Many historians have recorded the trade links between India, Greece and Egypt prior to Christian era. Archaeologists have tried to establish the overseas trade routes to Indus Valley culture. Thus Lothal and Chanhu-daro, the Indus cities are thought to have imported gold either from Hutti or Kolar through maritime routes for the manufacture of artifacts. This view is not totally accepted by all the archaeologists since there hardly exist any evidences of contact between the mature Indus cities in Sindh and the south Indian neolithic sites.

It is very much essential to exercise care before concluding the source of gold used by Harappans for the manufacture of artifacts. Unless large scale trace element studies is carried out for the artifacts as well as gold from the suspected source, this problem cannot be resolved.

10.2.15 Locations of rock edicts of Asoka offers an interesting field. In all, there are nine edicts in Karnataka alone distributed nearer to the source of gold. The name *Suvarnagiri* inscribed in Brahmagiri edict of Molakalmuru may point to Maski hill from Hutti area from where many ancients workings have been described. Added, Mauryan sites have been described from Maski area. This is further supported by Kautiliya's Arthasastra, wherein it is insisted that southern routes *Dakshinapatha* is preferred over Himalyan routes for gold. This clearly points that as early as 3rd century B.C. the Deccan was known for gold occurrence.

10.2.16 Geologists workings in South Africa have drawn analogy between the mines of Karnataka and gold mines from Rhodesia, it is opined that mining in the state of Mysore (Karnataka), India have provided the inspiration for the Rhodesian ancient workings to have developed from 3rd

century A.D. This observation is supported by the nature of ancient gold workings and frequent occurrence of tamarindus tree around many ancient workings in South Africa which is not indigenous to the country.

10.2.17 Hunkund in Kolar district is referred to as place where gold extraction was carried out in earlier days. But, the detailed examination of the site has proved it to be an iron smelting site, confirmed both by metallurgical and geological evidences.

10.2.18 Iron slag heaps occurring at or many ancient gold workings, though point to iron smelting have a bearing on mining, since, iron implements were needed to develop and deepen the mines, as is evidenced in Chiranahalli, Ettinahatti and Chinmalgund areas which are known for ancient gold workings.

10.2.19 Bellibetta in K.R.Pet taluk, Mandya district is proved to be an 'iron age' gold mine and it broadly sets guidelines for classification of other gold workings.

10.2.20 The available radio carbon dates for gold mines in Karnataka suggest the earliest date of gold mining to be the early Christian era (Hutti mines), while Kolar gold mines were active during 5th and 7th century A.D. This would only indicate the progress of mining but it is inferred that the initiation of mining could have been much earlier dating back to the neolithic settlements and intensified during iron age.

10.2.21 Gap in the records of mining need not necessarily point to the abandoning of mines. Though Kolar mines were active in 5th and 7th century A.D. no mention of it is made in the contemporary historical records.

10.2.22 Radio carbon dates of basemetals of Aravali range, indicate that as early as 1125 B.C. Rajpur Dariba copper mines were worked out while

lead and zinc mines in Zawar in Udaipur district have been mined around 415 B.C. which approximately corresponds to the Mauryan period.

10.2.23 The radio carbon dates for copper mines of Ingaldhal in Karnataka indicate two periods of mining activity, viz. 2070 ± 110 B.P. and 1820±100 B.P. which is contemporaneous with the progress of gold mining in Hutti gold field

10.2.24 The antiquity of gold mining in Karnataka, thus puts the clock back to the later phase of neolithic period (between the end of 3rd millennium B.C. and the first half of the 1st millennium B.C.) when the visible gold was picked up by the neolithic and the surface deposits were worked. The search for yellow metal continued and intensified in the iron age taking advantage of iron implements and culminated in deep development of mines in the historical period.

APPENDICES

APPENDIX - I

A BRIEF REVIEW OF GOLD MINING AND METALLURGICAL DEVELOPMENT

The discovery of the oldest treasure of gold from a grave in Bulgaria containing 2000 solid pieces of gold ornaments has pushed the antiquity of gold mining and metallurgy to 4000 B.C. Along with gold ornaments, flint tools, copper axe, decorated pottery, antler, sickles and bone tools have been described from the grave. The top layers have yielded bronze age artifacts (Colin Renfrew, 1980). Gold is believed to have been mined from the surface or near surface working in the Transsylvanian Alps of Romania (Parrish *et al.*, 1985).

Significantly the earliest gold comes not from reefs but placers. Since gold is having high specific gravity (19.3) it was easy to pan and collect the metal. We have very little evidence to trace the antiquity of gold mines prior to 4000 B.C.

The earliest undoubted placer mining comes from Egypt followed by Ethiopia. The Egyptian mines are dated to be around 3500 B.C. (Sutherland, 1960, Forbes, 1971)

Between 2000 and 1000 B.C. more placer deposits were worked in Transsylvania and Ireland, Mesopotamia and China. Present Turkey also practiced placer mining. Better improvements in the mining techniques were adopted by fire setting and quenching which was followed for centuries slowly shifted to reef mining. The Egyptian miners adopted sheep skin liners for collecting the fine particles of gold. Active mining of gold is depicted in the oldest survived map Turin papyrus, dated to be 1150 B.C. which is identified as El-sid mine of the Egyptian desert (Dunkun R Derry, 1951)

Harrell & Max Brown,(1992), Hume (1937), Sabet *et al* (1976) and Murray (1942) have interpreted that the mine depicted in the map is

undoubtedly the gold mine and this has been attributed to Romans (Meredith, 1953).

A significant achievement in gold metallurgy during this period, is the innovation of new technology of using mercury for amalgamation and employment of liquation technique to make impure gold ingot. In the latter method, ores were first smelted often with a siliceous flux to yield an impure ingot. This ingot was then alloyed with lead, and alloy heated to a temperature between the melting point of lead and copper, during which the lead would liquate out carrying the silver and gold with it. The lead was then coupled to bone ash (Boyle, 1979)

This period also marks the use of salt(NaCl) for parting gold from silver. With the employment of advanced technique, the production of gold enhanced and accounts to more than 15 tonnes of annual production (Kavanaugh, 1968)

There is a gap in the production of gold at the beginning of the Christian era (But Hutti and Kolar gold mines were active in the Indian subcontinent during this period). Historians, Diodoros (1st Century B.C.) Pliny(79 A.D.) have described reef mining in Spain. Diodoros in his writing *Bibliotheca historica* mentions gold placer and mines in many regions of Roman Empire and gives lucid accounts of the workings of gold and silver mines by slave labour at the time of Julius and Augustus Caeser. Pliny in his Encyclopaedic work *Historia Naturalis* mentions both placer and reef gold and also the constitution of gold (Boyle, 1987). The early mining in Ireland, Egypt, Lydia, Russia seems to have completely depleted by the turn of 8th century. This situation existed till the beginning of the 13th century, particularly the European mines saw the dark age of gold mining.

In the medieval period, Africa, Asia, South America and Central America were engaged in primary gold mining. The Spanish invasion of

Mexico and fall of Incas brought nearly 30 metric tonnes of gold to Spain. Columbian and the Brazil placer deposits gained momentum in the subsequent century. It is estimated that between 1492 to 1600 A.D. gold production from South America amounted to 40% of the world's output. It is surprising that no records exist for gold mining of the Indian mines during the medieval period. From 1500 to 1800 A.D. the production of gold gradually raised, mainly from the source of South America, Russia and North American mines. A significant brake through occurred in the later part of 18th century when chemical metallurgy brought a revolution in the method of gold recovery. During this period chlorination was widely employed to get gold chloride. The discovery of cyanidation in the later part of the 19th century added more gold by way of recovery (Dorr, 1976).

The gold rush in California in the middle part of the 19th century from placer deposits added more gold to the world reserve. This lead to the improvement in panning methods and discovery of primary gold in California and Australia, which added nearly 200 tonnes of gold annually. It was in the later part of the 19th century, that the Kolar and Hutti gold mines became operative. Kolar Gold Field has produced 795 tons of gold upto March, 1990. Of this, about 600 tons (76%) were produced between 1880 and 1940 and the peak gold production was 171 tonnes between 1901 to 1910 (Radhakrishna and Curtis, 1991).

Many deep gold workings including Kolar and Hutti are the results of discovery of ancient mines. The South African mines, by the end of the century produced 40% of the world's gold production.

The reef mining became common in most of the gold producing countries towards the end of 19th century and systematic search for auriferous lodes brought new gold prospects into light. On the one hand there were improvements in dredging equipments to win placer gold, at the same

time, employment of carbon to recover gold from cyanide samples made another significant metallurgical brake through which helped even to recover small particles of gold from the cyanide solution. A rapid change in the concept of origin of gold deposits were brought about by systematic field surveys which added the banded iron formations also as the source for gold mineralisation. The large output of gold in the present century is the result of combination of new technological development particularly in the field of chemical metallurgy with new discoveries of gold deposits. Today the total production of gold from Market Economy Countries (M.E.C.) is little more than 2000 tonnes annually.

APPENDIX II

Average gold content of natural materials

Geological material	Au (1 x 10^{-7} %) (ppb)	Literature source
Meteorites:		
Iron	50.0	Goldschmidt and Peters, 1932
Chondrites (iron)	100.0	Goldschmidt and Peters, 1932
Chondrites	170.0	Vinogradov, 1962
The Earth's crust as a whole	4.3	Vinogradov, 1962
The Earth's hydrosphere	0.01	Zvyagintsev, 1941
Sea water	0.8 to 5.0	Zvyagintsev, 1941
Sedimentary rocks (Clays and shales)	1.0	Vinogradov, 1962
Igneous rocks:		
acidic	4.5	Vinogradov, 1962
acidic	2.0	Vinogradov, 1962
basic	4.0	Vinogradov, 1962
basic	11.0	Shcherbakov, 1969
basic	1.0 to 9.0	Moiseenko et al, 1971
ultrabasic	5.0	Vinogradov, 1962
ultrabasic	8.2	Shcherbakov, 1969
Metamorphic rocks (slates)	0.7 to 4.2	Moiseenko et al, 1971

(Source : Gold - History and genesis of deposits. R.W. Boyle, 1987).

APPENDIX III

GOLD : INDIA AND THE WORLD

	1990	1991	1992	1993
Mine Production	**2.9**	**2.1**	**1.9**	**1.9**
World Total	2132.7	2160.7	2237.3	2281.1
Supply from fabricated old gold scrap	**60**	**70**	**75**	**91**
World total	524.3	460.5	462.8	535.2
Fabrication*	**240.6**	**233.7**	**307.0**	**284.0**
World total	2639.4	2816.2	3143.2	2986.6
Fabrication in Carat Jewellery*	**238.6**	**227.0**	**293.8**	**259.0**
World total	2145.3	2305.8	2693.3	2501.0
Fabrication in carat jewelley#	**178.6**	**157.0**	**218.8**	**174.0**
World total	1793.0	1957.5	2293.6	2061.2
Fabrication in electronics	**0.2**	**0.2**	**0.5**	**1.0**
World total	216.5	206.0	176.2	183.4
other inds. & Decorative uses	**1.8**	**2.5**	**8.7**	**19.0**
World total	72.2	71.7	86.6	96.6
Consumption of Jewellery*	**227.0**	**212.0**	**277.0**	**241.0**
Rest of the world	1918.3	2093.8	2416.3	2240.0
Identified bar hoarding	**9.0**	**19.0**	**50.0**	**25.0**
World total	223.5	252.4	272.5	136.9

Note : All figures are in tonnes
The figures in bold pertain to India
* - including use of scrap
# - excluding use of scrap

Source : Gold Fields Mineral Services; Gold 1994.

APPENDIX IV

Units of Weights of Gold

1	pennyweight	=	1.55 ppm/gm. (approx.)		
1	pennyweight	=	1.5552 grams	=	24 grains
1	gram	=	0.64301 pennyweight	=	15.43235 grains
1	avoirdupois pound	=	16 avoirdupois ounces		
1	troy pound	=	12 troy ounces		
1	troy pound	=	0.822857 avoirdupois pound	=	372.24176 grams
1	troy ounce (20 pennyweight)	=	1.09714 avoirdupois	=	31.1034807 grams
2240	avoirdupois lbs.	=	One long ton		
2000	" "	=	One short ton		
2204	" "	=	One metric ton	=	1000 kg.
1	troy ounce	=	2 2/3 tolas		
1	tola	=	180 grains		
1	tola	=	7 1/2 pennyweight	=	3/8 oz.
1	seer	=	80 tolas		
1	maund	=	40 seers	=	82 avoirdupois
1	Kilogram	=	1 seer 6 tolas		pounds
First grade colour		=	> 6 milligrams		
Second grade colour		=	3-6 milligrams		
Third grade colour		=	< 3 milligrams		
Value of 1 mg. of pure gold		=	0.00003215 x market price of pure gold per ounce		

APPENDIX V

IMPORTANT PROPERTIES OF GOLD

Metallic element of atomic number 79

Belongs to Group IB of Periodic table

Gold has no stable isotopes

Atomic weight	:	196.967
Crystallisation	:	Isometric (Octohedral)
Melting point	:	1063°C
Boiling point	:	2960°C
Sp. gr.	:	19.3
Valence	:	1,3
Hardness	:	2.5-3
Fracture	:	Hackley
Malleability	:	From 1 cm thick sheet 100,000 foils can be separated.
Ductility	:	1gram of Gold can be stretched upto 2.5 km length
Electronic Configuration	:	2-8-18-32-18-1
Electrical resistivity	:	(0°C) 2.06 microhom - cm
Gold 198	:	Radio active gold of mass number 198
Half life	:	2.7 days
Derivation	:	Neutron irradiation of the element
White gold	:	58% Au 17% Ni 7% Zn 17% Cu
Electrum	:	80% gold + 20% Silver.

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PLATES

Plate 1. Mineralised banded iron formation within the amphibolite (adit No.1) on the eastern slope of Gavigudda hill, Ajjanahalli. (650 m level).

Plate 2. Intersection of N-S drive and E-W cross cut with ancient gold working at the top, Gavigudda hill, Ajjanahalli (710 m. level).

Plate 3. Mortars for pounding the gold ore; location: west of cross cut (710 m level).

Plate 4. Ancient gold working located along the pitch of the ore body (depth 30 m) in oxidised banded iron formation.

Plate 5. Modern adit driven in banded iron formation at 680 m level.

Plate 6. Ancient gold working in sheared banded iron formation on the northern slope of Gavigudda hill.

Plate 7. Ancient gold working in sheared banded iron formation on the northern slope of Gavigudda hill.

Plate 8. Pounding marks on the stream bed (Greywacke) 1 km west of Bellara.

Plate 9. Ancient gold working in sheared BIF and greywacke, Basavanagudda, Bellara gold field.

Plate 10. Cup shaped depressions carved on the inclined face of carbonated metabasic dyke to collect fine gold, G.R. Halli, South block.

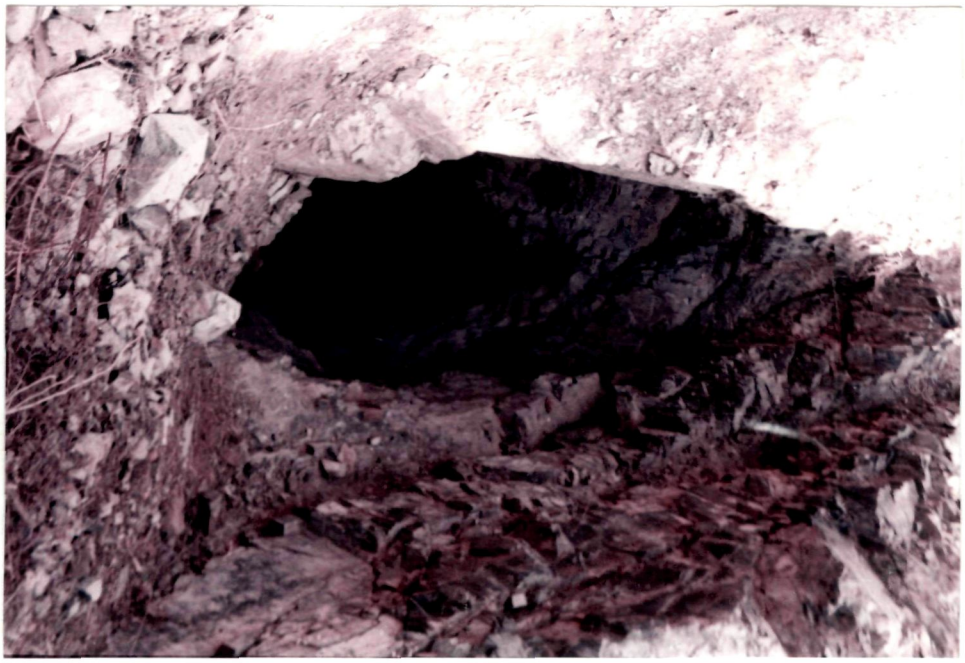

Plate 11. Narrow ancient gold working in carbonated metabasalt, G.R. Halli, South block.

Plate 12. Ancient gold working at the contact of metabasalt with acid volcanics. Hosur-Champion reef area, Gadag.

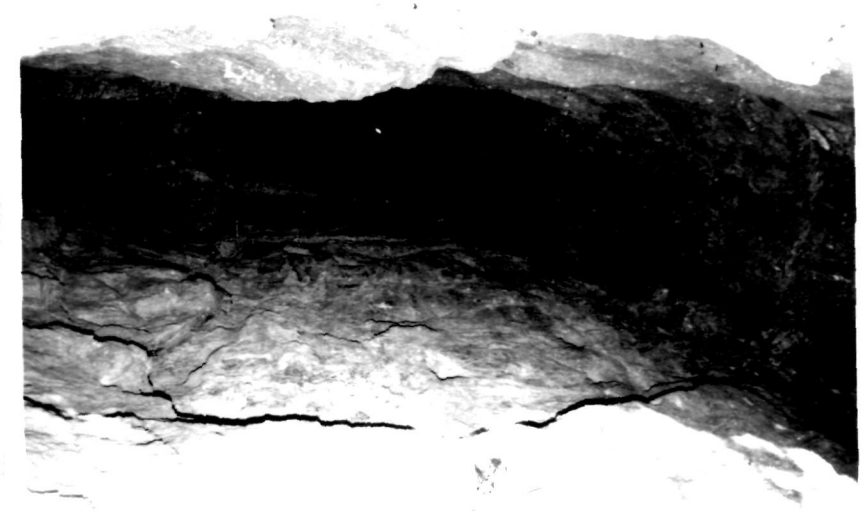

Plate 13. One of the deep ancient gold workings located on quartz ankerite vein, Budini, Hutti gold field.

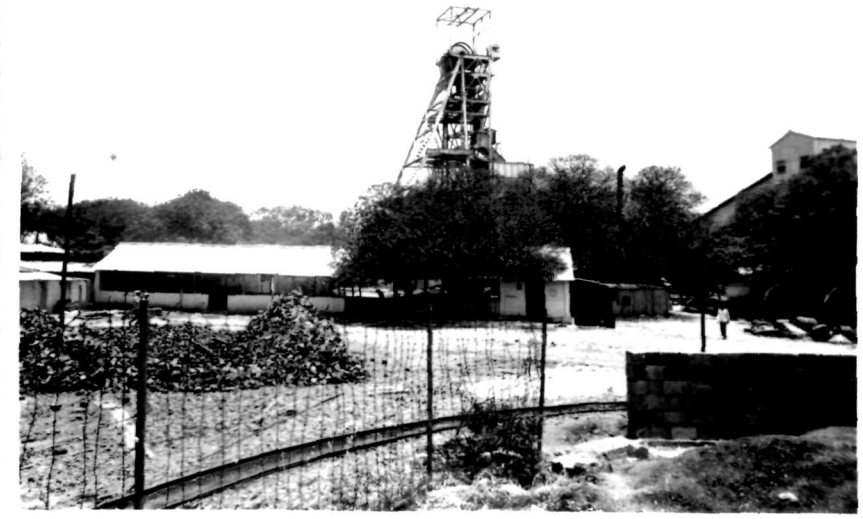

Plate 13a. Mallappa shaft headgear, Hutti gold field.

Plate 13b. Ancient gold working in carbonated metabasalt, Tuppadur block, Hutti gold field.

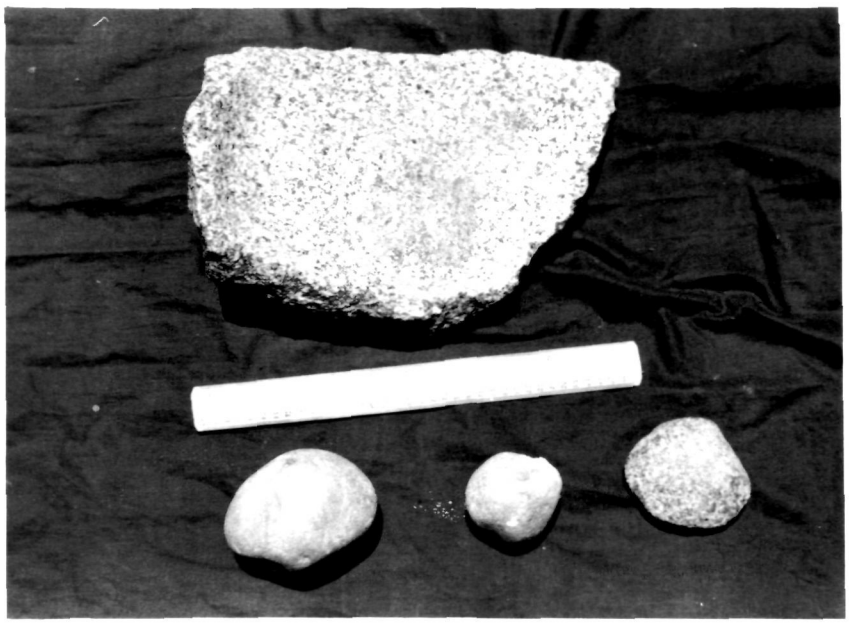

Plate 14. Polished rubbing stone (pink granite) and the grinding stones recovered from Wandalli ash mound.

Plate 15. Large rubbing stone (pink granite) near Wandalli ash mound.

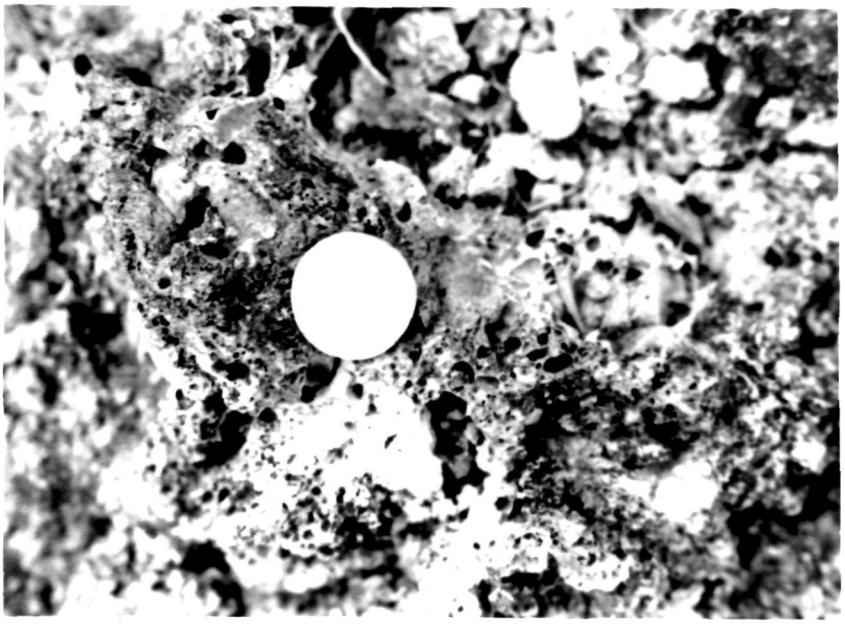

Plate 16. Highly vitrified ash layer, Wandalli ash mound, Hutti gold field.

Plate 17. Lumps of ash meterial exposed near Wandalli.

Plate 18. Partial view of highly solidified ash heap, Wandalli ash mound, Hutti gold field.

Plate 19. Bones of bovine and potsherds from Gaudur ash mound, Hutti gold field.

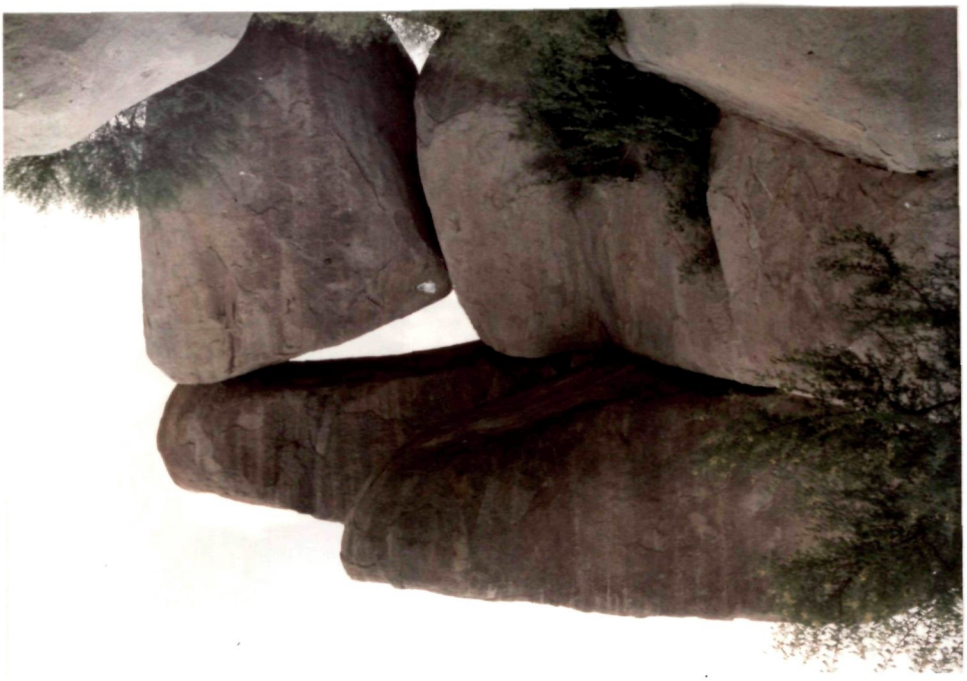

Plate 20. Highly jointed bolders of granite, Seethagudda, Patna, Kolar district.

Plate 21. Megalithic potsherds from diggings on the top of Seethagudda, Patna, Kolar district.

Plate 22. Grinding groove preserved at the top of Seethagudda, Patna, Kolar district.

Plate 23. Polished celt made of dolerite discovered near Someshwara temple, Hunkunda.

Plate 24. Vitrified urn (with finger print preserved) associated with iron slag, Hunkunda.

Plate 25. Tuyere with iron slag near the smelting site, Hunkunda.

Plate 25a. Tuyere recovered from smelting site, Hunkunda.

Plate 26. Ash used as binding material to fill the joint in a cave on the rear side of the Someshwara temple, Hunkunda.

Plate 27. Walls made of ash, Hunkunda village.

Plate 28. Solidified ash column preserved in the joints of coarse grained granite, east of Someshwara temple, Hunkunda.

Plate 29. Iron smelting site with Shrewn tuyere and slag, Hunkunda.

Plate 30. Someshwara temple of Chalukya period, east of Hunkunda.

Plate 31. Section of iron ore mine, 2 km east of Hunkunda.

Plate 32. Modern vertical shaft on the northern slope of Bellibetta, K.R. Pet taluk, Mandya district, intersecting mineralised quartz vein within the meta ultramafite.

Plate 33. Crow bar markings on the walls of Old working for gold in metaultremafite, Bellibetta.

Plate 34. Pounding marks on the metaultramafites adjacent to the old workings.

Plate 35. Pounding marks on the northern slope of Bellibetta hill.

Plate 36. Pounding marks near the vertical shaft, Bellibetta.

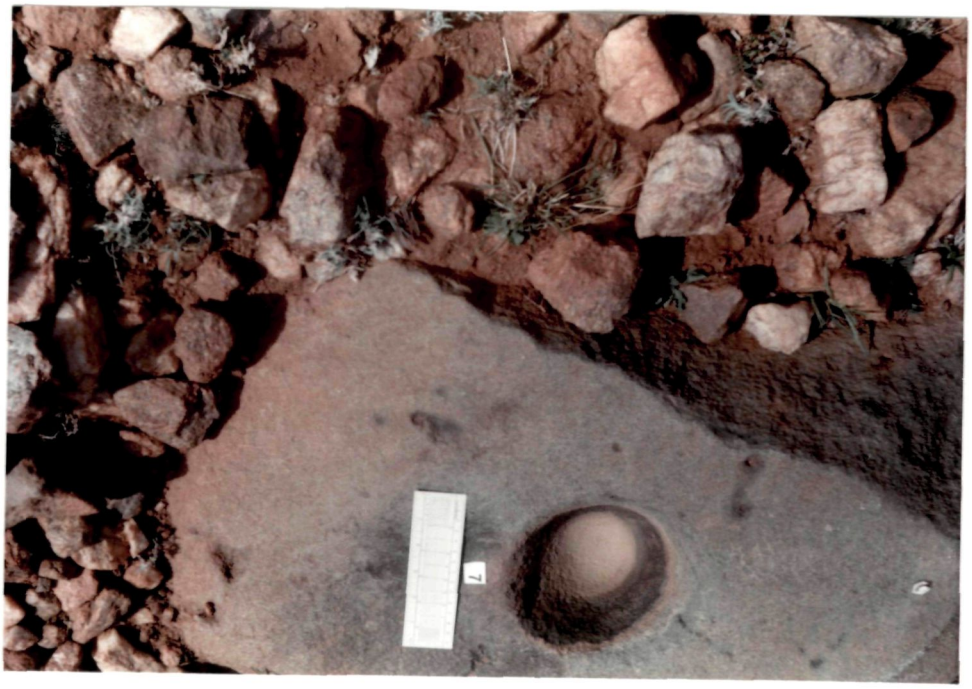

Plate 37. Pounding marks on the dolerite soulder at the Foothill of Bellibetta.

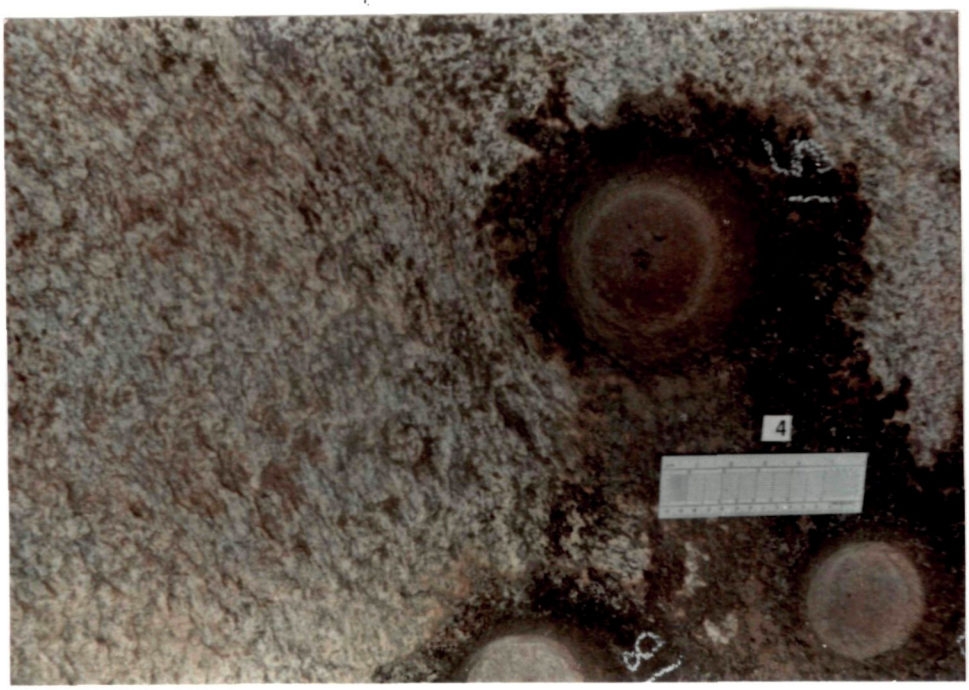

Plate 38. Group of pounding marks on the gneissic outcrop on the bank of nalla east of Bellibetta.

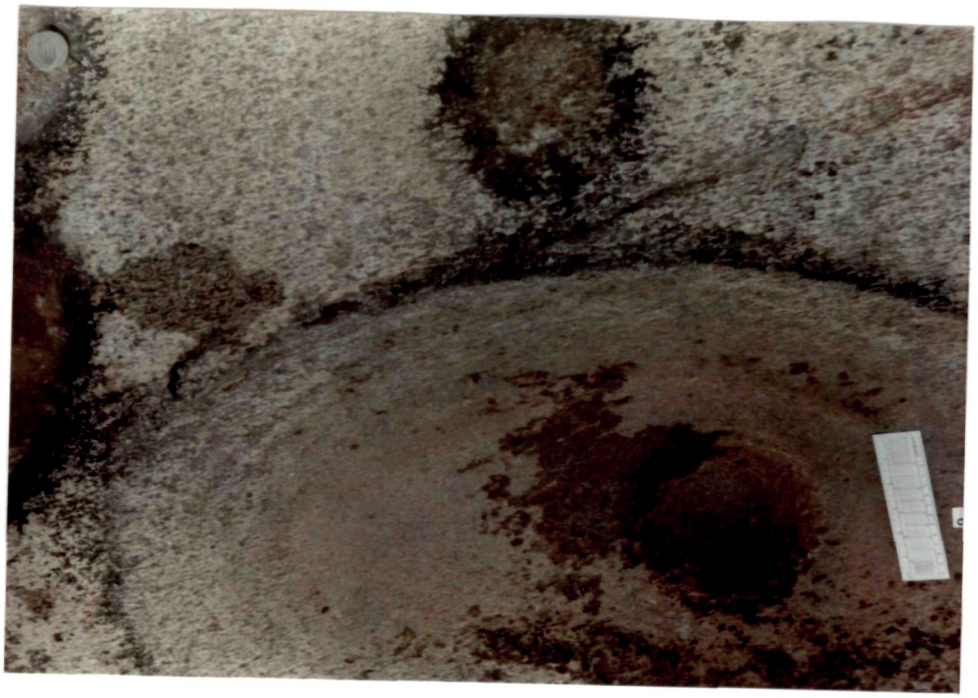

Plate 39. Polished rim of pounding marks on the gneissic outcrop.

Plate 40. Old timber (Babul) from the ancient gold mine of Hutti (age 1890 ± 50 B.P.): From the collections of Geological Museum, Hutti Gold Mines.

Plate 41. Pot (coarse red ware) received from Hutti main mine used by ancient miners for dewatering (1st century A.D.: From the collections of Geological Museum, Hutti Gold Mines.

Plate 42. Potsherds, of crucible and tuyere from Hutti main mine (form the collections of Geological Museum, Hutti Gold Mines).

Plate 43. Iron pestle recovered from the trench near Chikhersur (weight 2.25 kg).